Special Supplement
SMITHSONIAN ASTROPHYSICAL OBSERVATORY
BULLETIN NO. 1
FOR VISUAL OBSERVERS OF SATELLITES

Sky and TELESCOPE

In This Issue:

American Astronomers Report

Some Views of the 120-inch Telescope

The Berkeley Bevatron

The Star of Bethlehem

The First Determinations of Stellar Parallax — II

Stars for December

Vol. XVI, No. 2

DECEMBER, 1956

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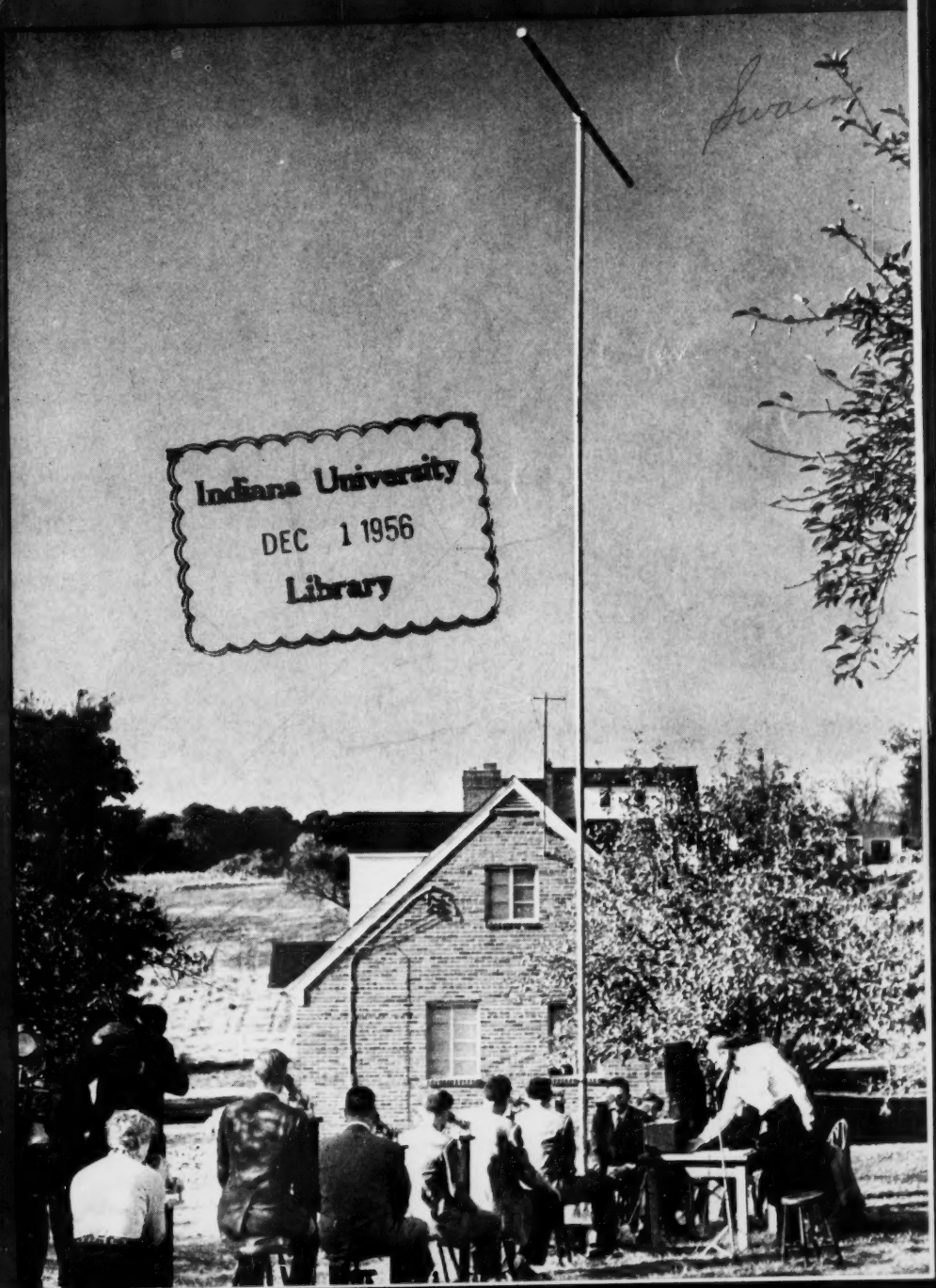

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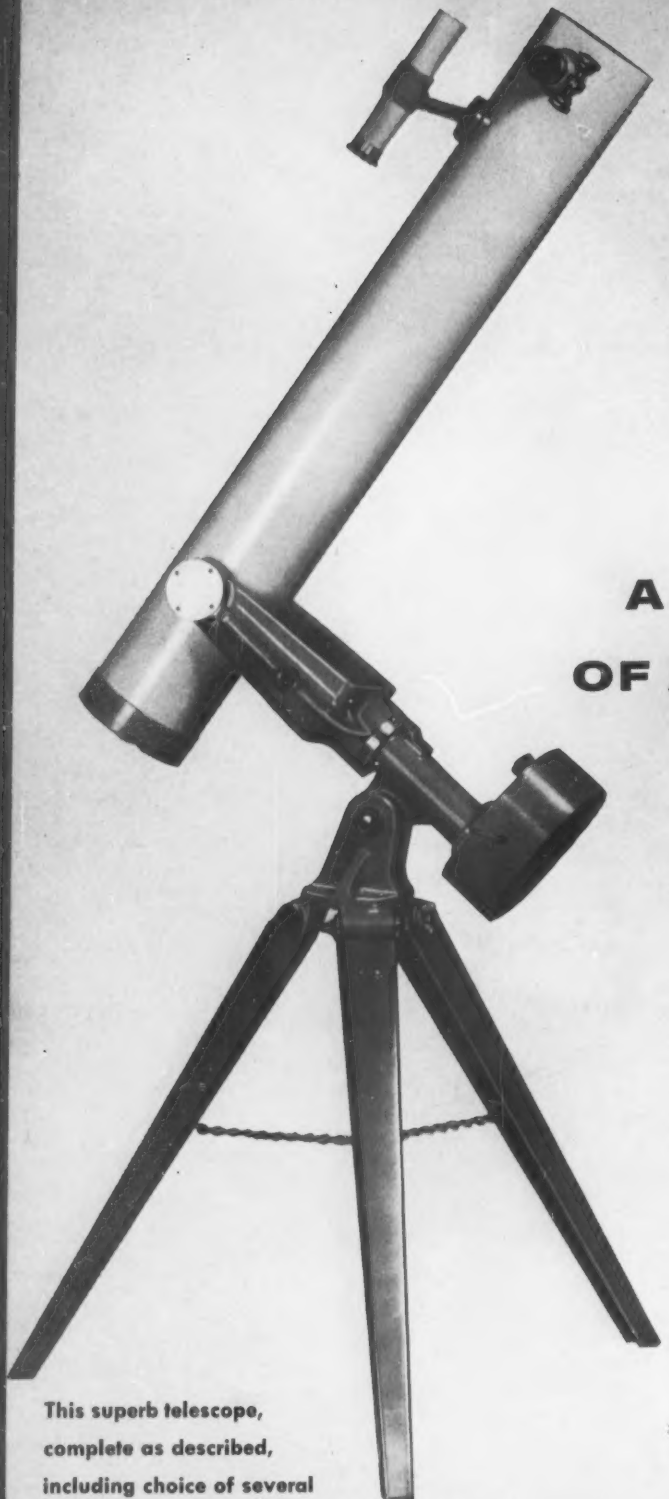

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The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

A Mars Party with the Washington Amateurs

A REPORT written by Tove Neville, of Arlington, Va., for the October issue of *Star Dust,* describing a Mars picnic, is representative of the experiences of many amateur societies throughout the country. Her account has been slightly shortened here:

The Mars picnic on September 9th turned out to be the biggest the National Capital Astronomers has ever had—but rightly so since we now have the largest membership in the history of our society; and it was indeed gratifying to see a great participation by our new members. Then of course, Mars is a great attraction these days, to all of us, and our meteorologists did provide just about the most perfect weather ever seen in these parts.

The few clouds in the sky in the late afternoon dared do nothing but disappear when 78 astronomers (including the kids) met at Manassas Battlefield Park. But just as we had hoped—without fingers crossed—it was so dark that we could hardly see any of the 16 telescopes or the people there, and we had to feel our way around. But we could see the Milky Way from horizon to horizon, and the whole sky looked like an inverted bowl of diamonds on black velvet.

Entire families came with their children, and the telescopes ranged from the juniors' Moonscopes to very fine, large instruments. It seems we saw everything the heavens could possibly offer. Before sundown several people looked at sunspots, and at twilight everyone was watching the moon going down and Mars coming up big and brassy.

Several people saw the polar caps of Mars but few claimed to see the markings, the reason postulated to be the present dust storms, which are also held accountable for the yellow color the planet had instead of the martial red.

Later we saw globular clusters, the Andromeda nebula, and numerous nebulae in Sagittarius. Ellis Marshall reported seeing three meteors, "bigger and brighter than ever before," and as we started home we saw one as a brilliant lantern falling from the northern sky. It was interesting to notice that two glowing objects kept descending after it had burned out.

Nearly everyone had brought a picnic supper, and astronomical quantities of coffee were consumed during the evening in the grove, where Trudy Dellar was most helpful with the coffeepot, as we kept the fires going while the temperature dropped down in the fifties. As we came back to town, the city lights obscured the seeing again and only Mars hung clearly as a beacon over our heads.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the joint meeting of the American Astronomical Society and the Astronomical Society of the Pacific at Berkeley, California, in August. Complete abstracts will appear in the Astronomical Journal *and the* Publications *of the Astronomical Society of the Pacific.*

The Sun's Brightness

The Henry Norris Russell lecture was given by Joel Stebbins, Lick Observatory, who told how he and G. E. Kron had measured the apparent magnitude, color, and temperature of the sun. These three data are of basic importance in astrophysics. Nevertheless, it is exceedingly difficult to place the sun accurately on the stellar magnitude scale, because it is 10 billion times brighter than the next brightest star, Sirius.

With a new device for reducing the sun's light by a known amount without changing its quality, and with the aid of a photoelectric cell, Drs. Stebbins and Kron first compared the sun quantitatively with a standard lamp, and with an electric furnace that served as a source of blackbody radiation. Then the lamp, shining through a pinhole set up on one of the peaks of Mt. Hamilton, was observed with a telescope 2,000 feet away, and this artificial star was compared photoelectrically for brightness and color with actual stars.

The apparent visual magnitude of the sun was found to be −26.73 on the international system, with a probable error of ±0.03, and its color index came out +0.53. The sun is actually about 10 per cent less bright than the generally accepted value, but the color index agrees exactly with that of other stars whose spectra match the sun's.

Thus, Dr. Stebbins found the sun's photovisual absolute magnitude to be +4.84—this is the apparent magnitude it would have if seen from a distance of 10 parsecs. When the color index of +0.53 is applied, the photographic absolute magnitude comes out +5.37.

Comparison of the sun with the lamp and the electric furnace at 3,000° absolute gives the sun a surface temperature of 6,400°. On the same scale, the Lick astronomers find the temperature of the hottest blue stars, such as those in Orion, to be as high as 25,000°.

All of these results fall within the range of previous determinations, but the use of the photoelectric cell has improved upon the accuracy of earlier visual and photographic methods.

The Unseen Companion of 61 Cygni

Known as a wide visual double star for two centuries, 61 Cygni consists of two bright stars separated by about 90 times the earth's distance from the sun and revolving around each other in about 720 years. In 1942 this system was found to have an invisible companion, by K. A. Strand, Dearborn Observatory. His photographic measurements of the two visible components showed periodic variations in their relative positions which he attributed to the gravitational influence of a third star revolving around one of them.

Dr. Strand has now completed 14 additional years of observation and analysis that confirm the existence of the dark star. It moves with a period of 4.8 years in an orbit 0.010 second of arc in radius. Its mass is 0.008 that of the sun, or only eight times the mass of Jupiter. Dr. Strand pointed out that the unseen 61 Cygni C could be regarded either as an exceptionally small star or as a planetary companion.

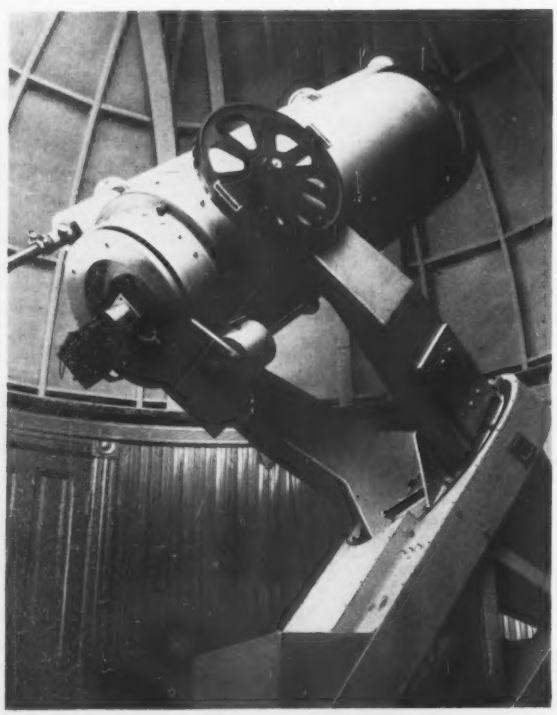
To arrive at these results, Dearborn Observatory astronomers made more than 200,000 measurements of over 17,000 photographic images on 232 plates taken with six of the world's largest refracting telescopes, at Potsdam, Lick, Sproul, Yerkes, Lowell, and Dearborn observatories. The 1942 study was based on 47 of these plates.

Ultraviolet Observations from Rockets

E. T. Byram and his collaborators at the Naval Research Laboratory, Washington, D. C., reported on the first successful observations from rockets of astronomical bodies other than the sun. The purpose was to survey the sky in far-ultraviolet light which cannot penetrate down through the lower atmosphere.

The first attempt was with an NRL Aerobee rocket, flown from White Sands Proving Ground, New Mexico, at 2 a.m. on November 17, 1955. The rocket, which rose to an elevation of 104 kilometers, carried collimated photon counters to detect ultraviolet light. One detector, covering the band from 1100 to 1340 angstroms (and therefore including the Lyman-alpha line of hydrogen at 1216) recorded a strong diffuse sky glow. But with a second counter, operating at 1220 to 1340 angstroms, discrete celestial sources were detected.

These were described in a second paper by J. E. Kupperian, Jr., and J. E. Milligan, also of NRL. The three strongest sources are the hot early-type stars Gamma Velorum, Zeta Puppis, and Regulus. This is in general agreement with predictions by R. J. Davis of the ultraviolet appearance of the night sky, summarized in our July, 1956, issue, page 400. In addition, there appear to be a small number of sources above the galactic plane, for which there is no obvious explanation. It was possible to measure the ultraviolet



This is the new 20-inch reflector of the Leuschner Observatory, University of California, built at Berkeley by Tinsley Laboratories. Its Newtonian focal length is 80 inches; the Cassegrainian effective focal length 320 inches. The 6-inch refracting telescope on the far side of the main tube is for guiding. The fork-type equatorial mounting is similar to that of the 18-inch Schmidt telescope at Palomar Observatory. Forthcoming accessories are a grating spectrograph being constructed by Edison Pettit, a photoelectric photometer, a double-slide plateholder, and a micrometer. Although available for research, such as recent work on variable stars, the telescope will be used mainly for teaching purposes.

brightness of each of the three stars mentioned, which will be compared with theoretical computations.

Successful ultraviolet photographs of the sun's disk, obtained from an Aerobee rocket at an altitude of about 150 kilometers on May 8, 1956, were reported by W. A. Rense, University of Colorado. The airborne camera had lithium-fluoride optics to image the sun in the light of the Lyman-alpha line. Although of low resolving power, the pictures show that active sunspot and plage regions were bright at this wave length. On the same flight, the spectrum of the sun was photographed, and from this record the intensity of the Lyman-alpha line could be reliably determined.

Dynamics of an Artificial Satellite

Several of the papers at the Berkeley meeting discussed artificial satellites of the earth, whose motion presents some novel problems in celestial mechanics. Interest centered in the perturbations of the satellite's orbit; these will be very large because of its nearness to the earth.

Since the earth is nonspherical (an oblate spheroid) the longest axis of the elliptical orbit will turn eastward in its own plane, while the line of nodes (the orbit's intersection with the plane of the earth's equator) simultaneously shifts westward. For natural satellites that move very nearly in the equatorial planes of their primary planets, these two shifts occur at nearly the same rate.

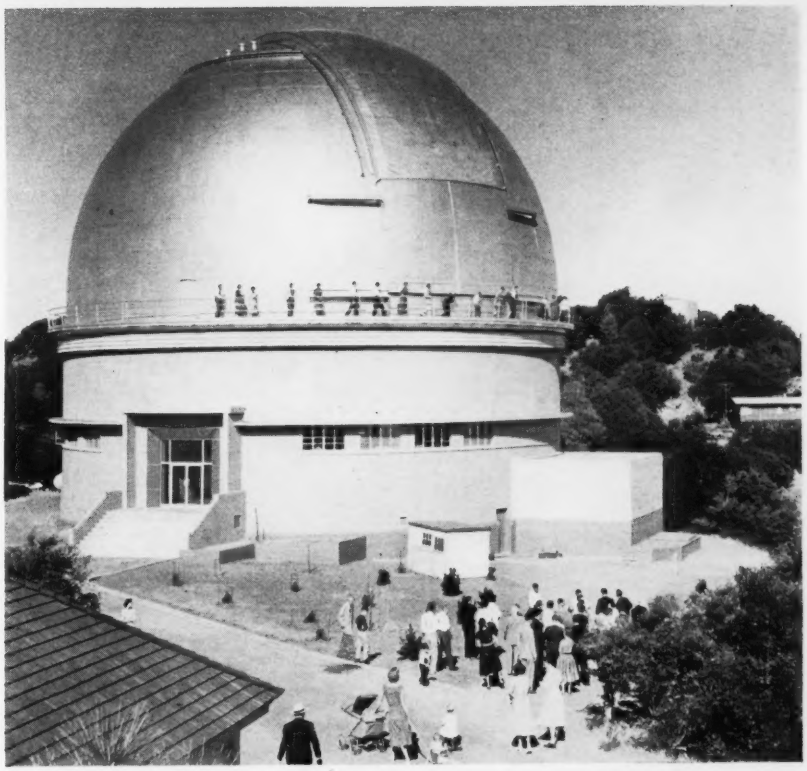
L. E. Cunningham, of the Leuschner Observatory and Smithsonian Astrophysical Observatory, pointed out that the situation will be quite different for an artificial satellite with the expected inclination of about 40 degrees. The eastward drift of its perigee will be considerably slower than the westward motion of the nodes. In fact, were the inclination to be greater than about 45 degrees, both perigee and nodes would move westward.

For an inclination of about 39 degrees, the daily eastward motions (in right ascension) of the sun and of perigee are equal, so the same point on the satellite's orbit would be observable repeatedly in a given twilight zone. The observations would tend to cluster around two points of the orbit; if this clustering were too concentrated the accuracy of orbit determinations would be markedly decreased.

The proposed orbit of the first satellite in the International Geophysical Year program has nearly this critical inclination. However, the relations involved are not likely to be fulfilled accurately, and the intervals between morning and evening twilight change with latitude and with the seasons.

T. E. Sterne, Smithsonian Astrophysical Observatory, suggested a means for simplifying calculations of the satellite's motion. For natural satellites, the motion is usually first computed as if the planet were spherical; then the corrections arising from the planet's oblateness are calculated and added in. But for an artificial satellite moving close to the surface of the earth, these corrections become much more complicated and difficult to evaluate. Dr. Sterne proposed using an equation of motion that from the start allows for the earth's oblateness.

In another paper, J. A. O'Keefe and



On Sunday, August 26th, society members were invited to bring their families to Mt. Hamilton as guests of Lick Observatory at a picnic supper in the shadow of the new 120-inch reflector. They were taken on a tour of the entire building, including the catwalk outside the 97-foot dome, as this picture shows. A full-page picture of the 120-inch instrument faces page 60, and on pages 62 and 63 are additional photographs of the observer's cage and the mirror-supporting system. Another highlight of the meeting was an inspection tour of the University of California's giant bevatron, at the Radiation Laboratory in Berkeley (see pages 64 and 65).

The joint sessions were held in Dwinelle Hall of the University of California. In this picture, Dr. Bart J. Bok, Harvard Observatory, is speaking, while Dr. Harold L. Weaver, Leuschner Observatory, is chairman.

The joint meeting of the American Astronomical Society and the Astronomical Society o

KEY TO PHOTOGRAPH

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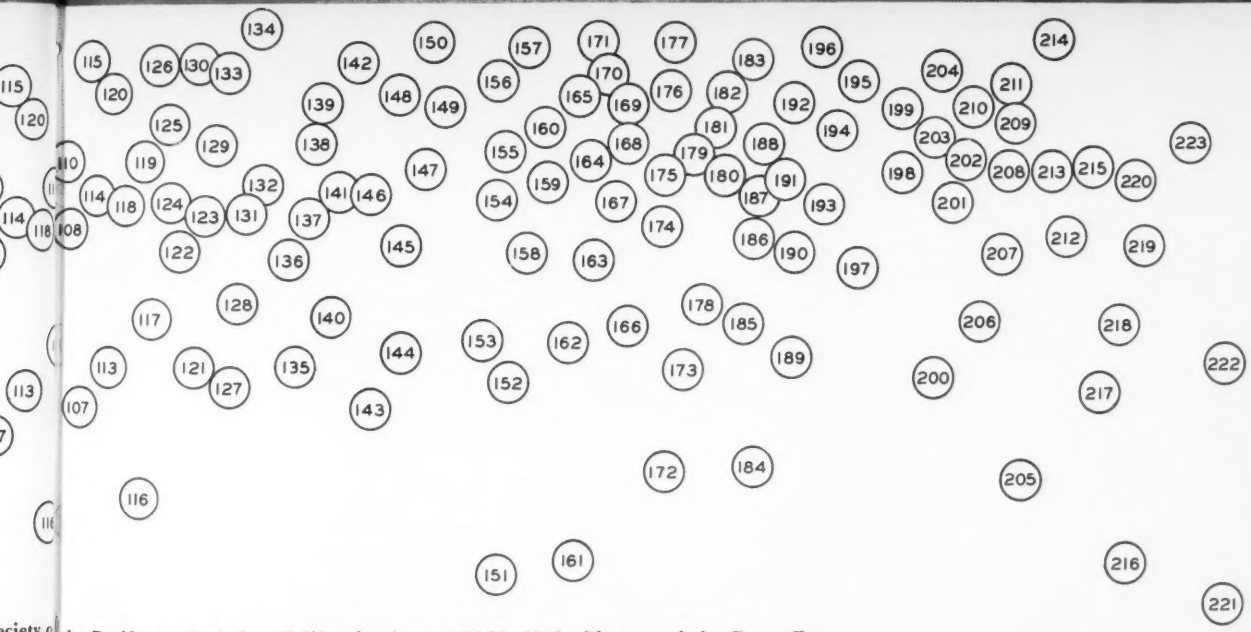

the Pacific, at Berkeley, California, August 24-28, 1956. Photograph by Barry Evans.

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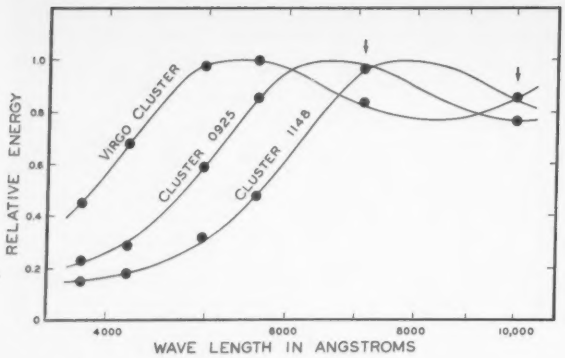
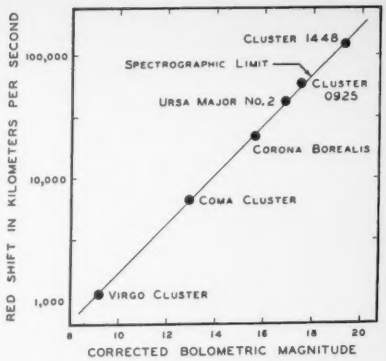


At the left, the relative energy per unit wave length is plotted against wave length on a logarithmic scale. Each curve is determined from photoelectric observations in six colors; the arrows indicate overlapping points. Dr. Baum's plot of the velocity-apparent magnitude (velocity-distance) relation is at the right.



C. D. Batchlor, Army Map Service, explained how the motion of a close satellite would be affected by the fact that the earth's equator is not precisely circular. They showed that a very small, twice-daily oscillation of the line of nodes would result. This effect would presumably be large enough to be detected by accurate photographic observations of the satellite.

Red Shifts of Faint Galaxies

Hitherto the red shifts of remote galaxies have been determined by photographing their spectra. With the 200-inch reflector, galaxies as faint as the 18th magnitude can be so observed, giving reliable red shifts that correspond to velocities of recession as high as 60,000 kilometers per second—a fifth of the speed of light.

For fainter galaxies, however, the required exposures are so long that the spectrum of the night sky drowns out the features of the galaxy's spectrum. W. A. Baum, Mount Wilson and Palomar Observatories, pointed out that there is thus about a four-magnitude gap between the spectrographic limit and the faintest galaxies detectable by direct photography. He has therefore proposed a photoelectric method to bridge this interval.

Dr. Baum used the photon counter (described by him in *Sky and Telescope* for June, 1955) attached to the 200-inch telescope. Employing color filters, he measured the relative brightness of a number of galaxies at six different wavelength regions. Thus, he could tell how far toward the red the continuous background spectrum was shifted, and from this infer the apparent velocity of recession in each case.

In the left-hand diagram, the first curve on the left is for the mean of four elliptical galaxies belonging to the Virgo cluster, which is relatively nearby and is not appreciably red-shifted. The middle curve represents the mean of two galaxies in a remote cluster, which is near the practical limit of spectrographic observations and which has a red shift of 19 per cent of the speed of light.

The third curve (which has two points in common with the second) is the mean of two galaxies in a still more distant cluster beyond the range readily available to the spectrograph. Its red shift is 40 per cent of the speed of light, or 120,000 kilometers per second, on the basis of the amount the curve is shifted with respect to the curves for the other clusters.

The positions of clusters 0925 and 1448 on the second chart confirm the linear character of the relationship between red shift and apparent magnitude. Each cluster is represented by an average point; the line drawn through the points is perfectly straight.

The uncertainty of Dr. Baum's measured red shifts may be as much as 10 per cent. Any of the points plotted in the second diagram would be moved only a fourth of its own diameter by an error of 1/10 magnitude in the bolometric luminosity or by an error of five per cent in the red-shift measurement. Therefore, on the basis of this work the velocity-distance relation, which is the observational basis for belief in the expanding universe, may be considered to be extended to twice the distance and to velocities of 2/5 the speed of light.

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136, W. Markowitz, USNO; 128, Mrs. Markowitz; 116, Toby Markowitz; 202, R. Mathews, Carleton; 52, T. Matthews, MWP; 64, Mrs. Matthews; 32, N. Mayall, Li; 195, C. Mayer, NRL; 192, Mrs. Mayer; 47, Miss J. Mawby, SF; 95, A. Meinel, Phoenix, Ariz.; 40, K. Menon, H; 127, D. Menzel, H; 185, Mrs. Menzel; 158, J. Merrill, Ohio Wesleyan; 29, P. Merrill, MWP; 43, Mrs. P. Merrill; 105, A. Mikesell, USNO; 90, Mrs. Mikesell; 2, Barbara Mikesell; 1, Jerry Mikesell; 99, John Mikesell; 88, Stephen Mikesell; 163, W. Miller, S.J., Fordham; 106, J. Milligan, NRL; 176, F. Mitchell, Ala; 209, M. McCarthy, S.J., St. Roberts Hall; 19, W. McClenahan, Dominion Obs.; 164, S. McCuskey, Case Inst. of Tech.; 143, A. McKellar, DA; 86, D. McNamara, Brigham Young; 119, G. McVittie, Illinois; 70, W. Morgan, Ye; 60, D. Morton, DD; 177, A. Mowbray, C; 175, G. Münch, CIT; 94, J. Mutschlecner, Michelson Lab.

156, J. Nassau, WS; 114, S. Nicholson, MWP.

13, G. Omer, Florida; 96, F. Orrall, SP.

76, C. Perry, China Lake, Calif.; 18, R. Petrie, DA; 110, A. Pierce, McMath-Hulbert; 6, Miss H. Pillans, Le; 73, L. Plaut, MWP; 132, D. Popper, UCLA; 124, Roger Popper; 183, A. Poveda, C; 134, G. Preston, C.

187, G. Reeves, SC; 149, A. Recht, Ch; 87, F. Roach, NBS; 63, M. Roberts, Le; 59, P. Routly, Pomona; 69, Mrs. Routly; 181, J. Russell, SC.

199, J. Sahade, Le; 72, W. Salisbury, Palo Alto, Calif.; 223, M. Schmidt, MWP; 56, Miss E. Scott, Le; 68, R. Sears, I; 41, C. Shane, Li; 191, W. Shane, C; 152, J. Stebbins, Li; 54, H. Sen, Air Force Cambridge Res. Center; 21, C. Seyfert, V; 98, C. Silvernail, San Diego, Calif.; 109, C. Smith, San Diego State; 155, H. Smith, SP; 147, Mrs. Smith, SP; 146, A. Spitz, SA; 53, U. Steinlin, C; 120, C. Stephenson, Le; 108, T. Sterne, SA; 37, S. Stone, C; 140, K. Strand, D; 42, Miss J. Streeter, Office of Naval Research; 162, O. Struve, Le; 23, Miss H. Swope, MWP.

217, G. Tauchmann, San Leandro, Calif.; 4, R. Taylor, SF; 150, N. Thomas, C.; 78, W. Tifft, CIT.

26, T. Vanasek, Walnut Creek, Calif.; 122, G. Van Biesbroeck, Ye; 210, S. Vasilevskis, Li; 8, A. Velghe, H; 7, Mrs. Velghe; 11, Brita Velghe; 20, Dirk Velghe.

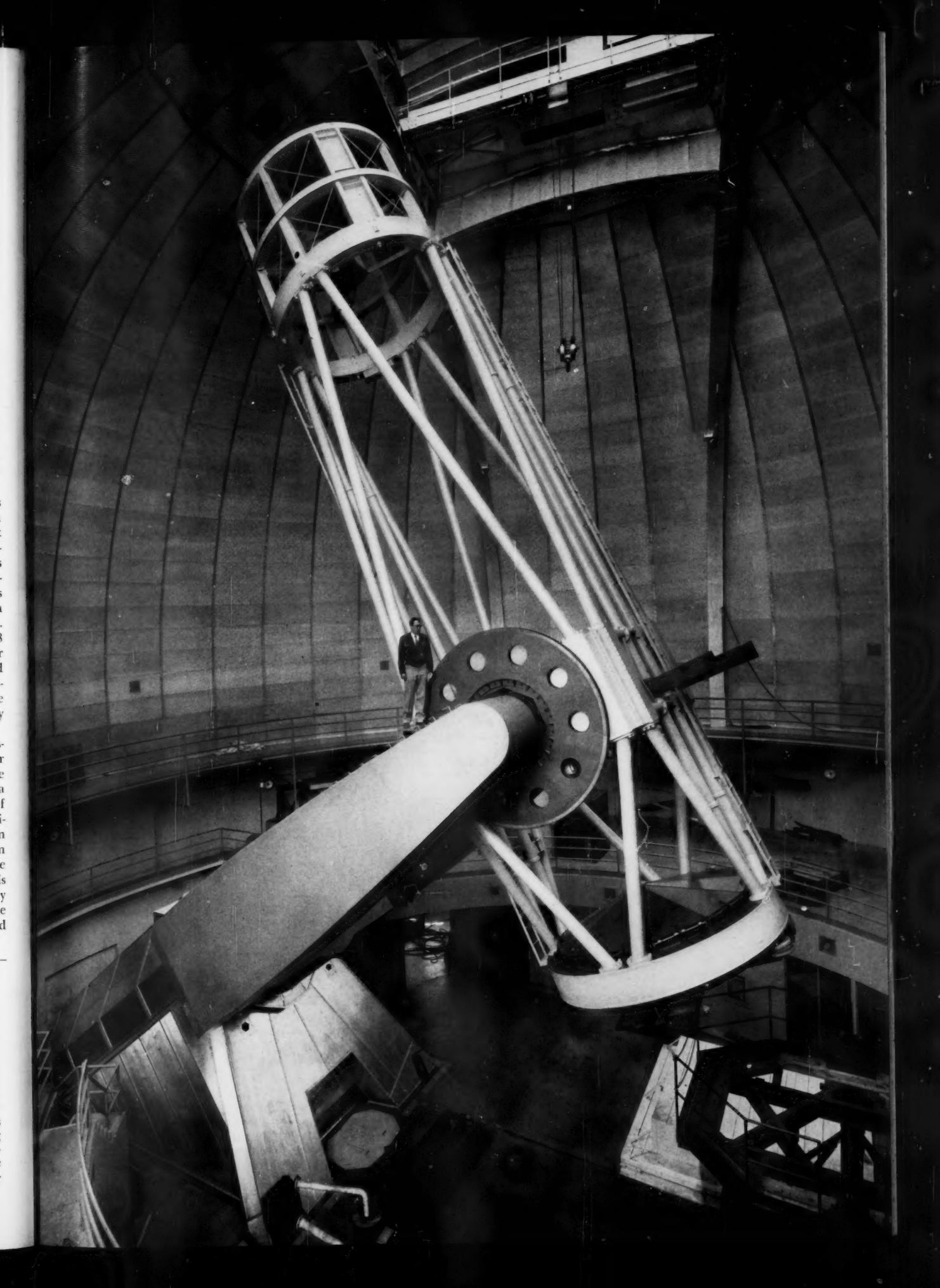
141, M. Walker, WS; 115, J. Warwick, HA; 112, Mrs. Warwick, HA; 125, D. Watson, Cincinnati, Ohio; 117, H. Weaver, Le; 101, W. Wehlau, Western Ontario; 113, Mrs. Wehlau; 92, F. Whipple, H; 196, H. White, C; 61, M. White, NBS; 182, R. Whitehurst, Ala; 219, R. Wilson, NRL; 212, Mrs. Wilson; 205, Kristin Wilson; 188, G. Wlerick, HA; 174, F. Wood, Pa; 85, M. Wrubel, I; 74, A. Wyller, Sproul.

31, K. Yoss, Louisiana State.

159, H. Zirin, HA.

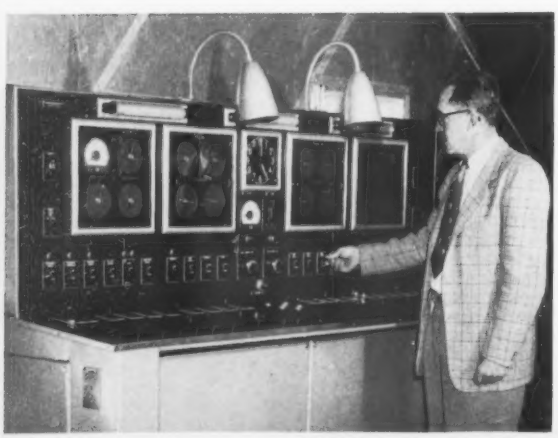
Ala, Alabama; AUI, Associated Universities, Inc.; C, California; Ch, Chamberlin; CIT, California Institute of Technology; D, Dearborn; DA, Dominion Astrophysical; DD, David Dunlap; H, Harvard; HA, High Altitude; I, Indiana; LA, Los Alamos Sci. Lab.; Le, Leuschner; Li, Lick; M, Michigan; MWP, Mount Wilson-Palomar; NBS, National Bureau of Standards; NRL, Naval Research Laboratory; Pa, Pennsylvania; SA, Smithsonian Astrophysical; SC, Southern California; SF, San Francisco, Calif.; SP, Sacramento Peak; UCLA, University of California, Los Angeles; USNO, U. S. Naval Observatory; V, Vanderbilt; WS, Warner and Swasey; Ye, Yerkes.

FACING PICTURE: The interior of the 120-inch building at Lick Observatory, with W. W. Baustian standing on one of the fork arms next to the declination circle. In the lower left is the aluminum housing over the polar-axis assembly. In the lower right is the carriage for handling the mirror cell; beyond and beneath this is the temporary (white) hatch cover over the 120-inch grinding machine that is located beneath the main observing floor. See pages 62 and 63 for close-ups of the observer's cage and the mirror-supporting system. Lick Observatory photo by J. F. Chappell.



In this view of the dome of the 120-inch from the southwest, the telescope is seen through the fully opened shutters. Extending across the lower part of the slit is the elevator that carries the observer to the telescope's prime focus. Inside the top of the dome is a crane. All photographs on this and the opposite page are courtesy Lick Observatory.

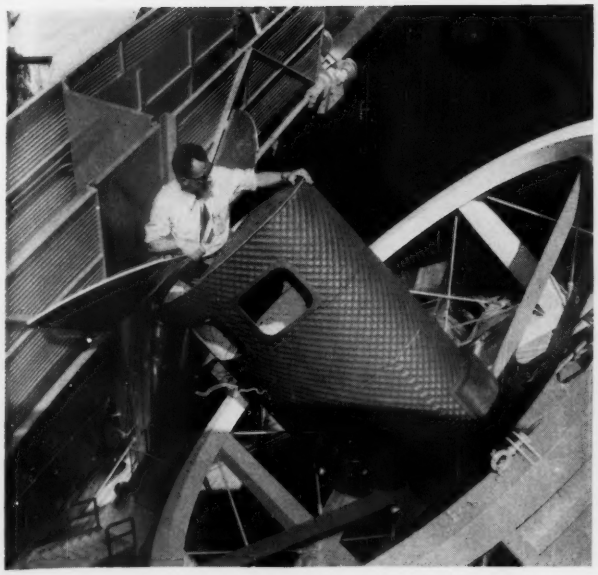
SOME VIEWS OF THE 120-INCH TELESCOPE



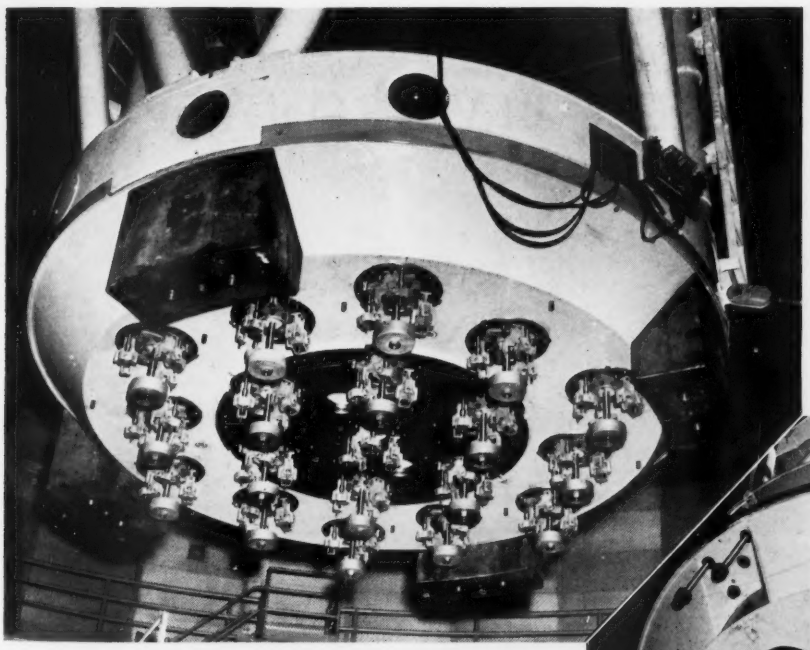
W. W. Baustian, engineer in charge of building the 120-inch, stands beside its control console. Left to right, the four panels include remote indications of dome azimuth, telescope zenith distance, vertical counterweight position; hour angle and right ascension; sidereal time and declination; declination driving rate, secondary focus position, and the tilt of the coude diagonal flat.

LICK OBSERVATORY, situated atop Mt. Hamilton in California, has a large array of telescopes, including a 36-inch refractor and the 36-inch Crossley reflector. But in recent years a shining new dome has been built, housing the second largest telescope in the world, pictured on the preceding page.

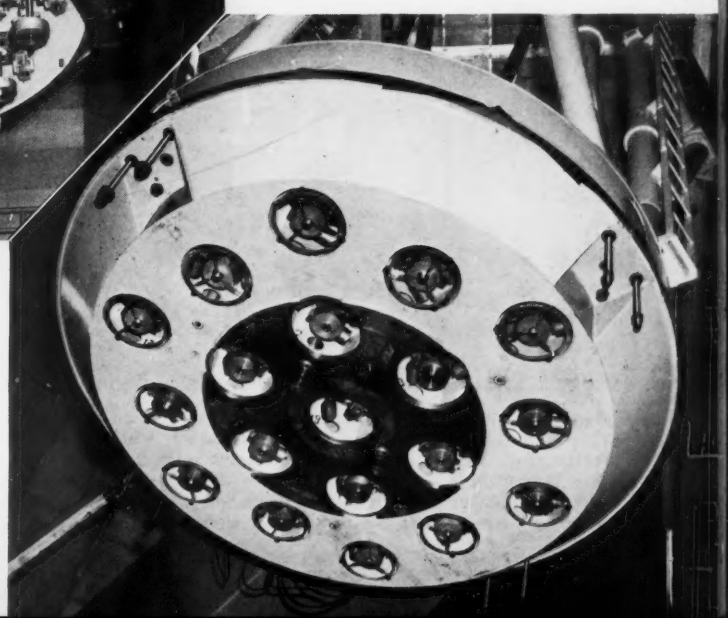
A pictorial history of the erection of this instrument and its dome appeared in *Sky and Telescope* for March, April, and May, 1955. This *120-inch Lick Album* is currently available as a separate reprint; the pictures in it were taken by J. F. Chappell, recently retired Lick photographer, who has been succeeded by R. E. Watson. The views on these two pages, which supplement those in the 1955 series, were taken either by Mr. Chappell or Mr. Watson.



When the 120-inch telescope is used for prime-focus observations, the observer himself rides inside the prime-focus cage at the upper end of the tube. At the left, Mr. Baustian is entering the cage from the elevator, whose access door behind him is already closed. Note the protecting "wings" that can prevent a serious accident to the observer. On the right, Mr. Baustian is inside the cage, which is supported by the top set of struts converging toward the center of the tube. The lower set, converging at the center of the ring girder, supports the optical parts of the prime-focus assembly. A counterweight that can travel around the ring girder balances the weight of the observer's cell, which is not on the axis of the tube.



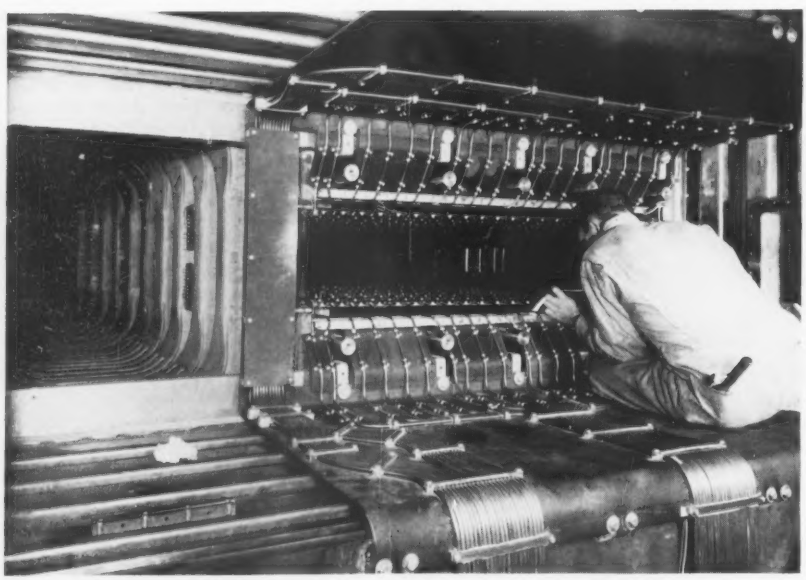
Provision for overcoming sagging of the primary mirror under its own weight is one of the most critical problems in the design of a large reflecting telescope. While the front surface of the 120-inch mirror is only $2\frac{1}{2}$ inches thick at the center, it has a ribbed back that gives great strength while allowing a considerable reduction in weight. The 18 units seen in these pictures fit into pockets in the ribbed structure, supporting the backs and inside surfaces of the ribs, to help maintain the mirror's shape for all positions of the telescope.



The picture above shows the supporting units partially withdrawn from their pockets. As the mirror is not in its cell, four large trim weights are in place, to preserve the balance of the telescope tube. At the right, with the mirror inserted, the trim weights are removed, and the supporting units are raised into place. The three radial springs in the 12 outer units are temporarily installed to take lateral load imposed by the tool during polishing of the mirror.

The University of California's Radiation Laboratory is just up the hill from the Berkeley campus where the American Astronomical Society met. In the center of the picture, the circular building houses the bevatron, the largest accelerator in the world for studies of atomic nuclei and high-energy elementary particles. Above this building and to the left is a circular domed structure, partly hidden by trees, that contains the 184-inch cyclotron. All photographs on these pages are courtesy University of California.

THE BERKELEY BEVATRON



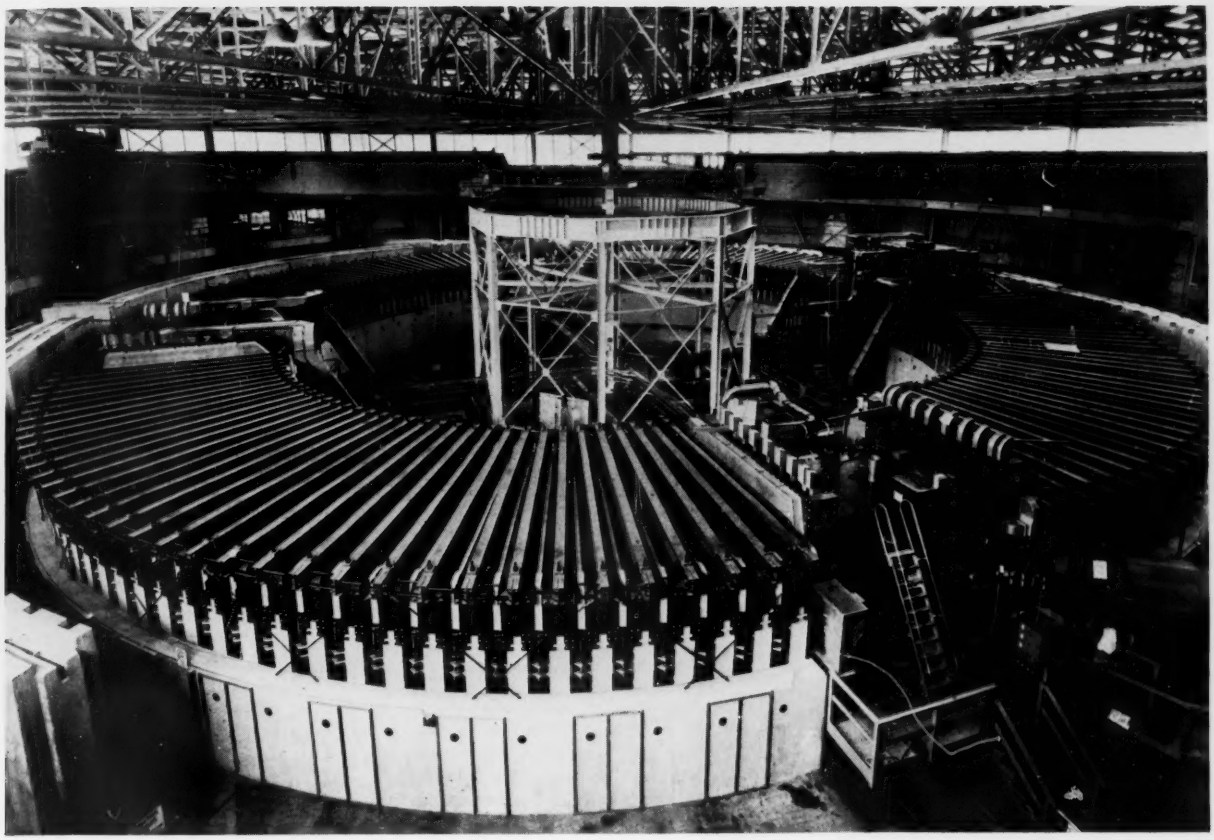
As the bevatron was nearing completion, a technician worked on the huge ring-shaped magnet, 135 feet in over-all diameter, which forms the heart of the instrument. He is at the aperture of the vacuum chamber in which the particles travel. At the left is the crawl space that gives experimenters access to the vacuum chamber without taking the whole magnet apart. Ports in the crawl space permit the insertion of experimental equipment into the chamber.

IT WAS very appropriate that the American Astronomical Society met in Berkeley almost in the shadow of the bevatron. Nuclear physicists and astronomers work on related problems—the stars are vast nuclear reactors, and it has been suggested that our galaxy, with its magnetic field, acts as a particle accelerator to produce cosmic rays.

Since its founding in 1936, the Radiation Laboratory of the University of California has played a major part in probing the atomic nucleus and studying fundamental particles. Under the sponsorship of the Atomic Energy Commission, a series of experimental devices of increasing power was developed, culminating in the bevatron.

Basically, this apparatus is an electromagnet 135 feet in over-all diameter, which forces protons to travel repeatedly through a ring-shaped tube as they are accelerated. The protons are first formed by an electric arc in hydrogen gas, and are speeded up to half a million electron volts in a Cockroft-Walton accelerator, and then to 10 million electron volts by a linear accelerator before injection into the bevatron.

When the protons enter the bevatron,



This view of the bevatron can be compared to the diagram below, with a 180-degree change in orientation. To the lower right of the 10,000-ton ring-shaped electromagnet a scientist stands beside the linear accelerator, which feeds protons of 10 million electron volts energy into the bevatron. Repeated accelerations speed these particles to 6.2 billion electron volts in 1.8 seconds. During this time the protons have traveled 300,000 miles, in a path 100 feet in diameter.

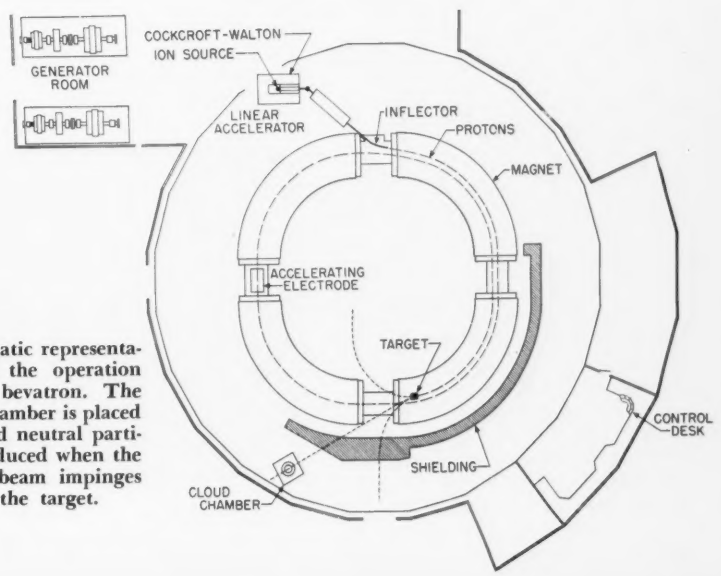
a magnetic field of only 300 gauss will keep them in their orbits. But on each revolution, they receive a kick while passing through a box-shaped electrode. In 1.8 seconds, the protons have circled approximately four million times, and are moving with 99 per cent the speed of light. A magnetic field of 15,500 gauss is now needed to hold the protons in their circular paths. At the end of this cycle, a pulse of protons with 6.2 billion electron volts of energy has been formed; there are 10 such pulses per minute.

The pulse impinges on a target, chosen for the particular experiment, and the particles produced are recorded by photographic emulsions, counters, and cloud chambers.

Important recent discoveries with the bevatron are the antiproton (see *Sky and Telescope,* March, 1956, page 204) and the antineutron, a fundamental particle similar to the neutron but with opposite spin. Experiments in this series were in progress during the visit of the astronomers to the Radiation Laboratory.

The antineutron was discovered by a four-man team of scientists, working under Dr. J. E. Lofgren, who is in charge of the bevatron. In their experiments they made use of antiprotons produced by the bevatron. If an antiproton makes an extremely close encounter with a proton, they combine to form a meson; in a less close encounter the antiproton is converted into an antineutron.

An even more powerful accelerator than the bevatron is under construction in Russia, and is expected to be in operation in 1957. It is intended to produce particles with energies as high as 10 billion electron volts.



A schematic representation of the operation of the bevatron. The cloud chamber is placed to record neutral particles produced when the proton beam impinges on the target.

The Star of Bethlehem

CARL P. RICHARDS

Could the first Christmas star have been a combination of such striking objects as Comet 1947n and Venus? They are drawn here by Rubens de Azevedo, Fortaleza, Brazil, as they appeared on December 13, 1947.

LEGEND, miracle, or scientific fact? Around these three themes there has ranged the still unsettled controversy of the explanation of the "star in the east" seen by the Wise Men at the time of the birth of Christ. Each year at the Christmas season renewed efforts are made to interpret this event of nearly two thousand years ago.

Throughout the centuries the scanty record of the Star of Bethlehem has been food for skeptics, confirmation for believers in miracles, and a stimulation to research for those with scientific leanings. Some people regard the story of the star merely as the product of a vivid imagination, prompted by religious enthusiasm; this is the course pursued by the skeptics. Others attribute the occurrence to the supernatural, and therefore beyond scientific description.

To those who want explanations in the light of modern knowledge, however, any bewildering phenomenon such as this is a challenge. The general order of the universe and our experience with observations of celestial phenomena suggest that some natural event might account for the story of the star.

Just what is this story, handed down through the ages? It is very meager and limited entirely to the first few verses in the second chapter of the Gospel according to St. Matthew. In the King James version the significant verses read:

> . . . behold, there came wise men from the east to Jerusalem, Saying, Where is he that is born King of the Jews? for we have seen his star in the east, and are come to worship him. . . .
>
> Then Herod, when he had privily called the wise men, enquired of them diligently what time the star appeared. And he sent them to Bethlehem . . . . they departed; and, lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was. When they saw the star, they rejoiced with exceeding great joy. . . .

Brief as this account is, it has had tremendous appeal to multitudes down through the years as a symbol of the advent of Jesus. The Wise Men were reputtedly well versed in the lore of the heavens and, crude though their learning was compared with today's, their knowledge has much bearing on a full appreciation of the story and our search for a scientific identification of the star.

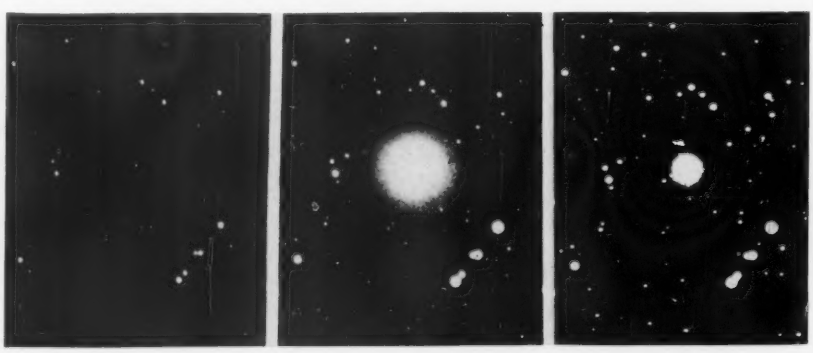
The exact date on which Jesus was born is not known. But from contemporary events mentioned in the New Testament story, His birth must have been during or before the year 4 B.C.—the year King Herod died—and possibly as early as 11 B.C.

Naturally, the planet Venus has been suggested as being the star that the Wise Men saw, as it is one of the most prominent objects in the sky, brighter than any other except the sun and the moon. This planet would provide a "sign" of outstanding beauty and brilliance. Its appearance, too, could occur within the years in question, as it shines very brilliantly in the morning eastern sky at regular intervals of just over a year and a half.

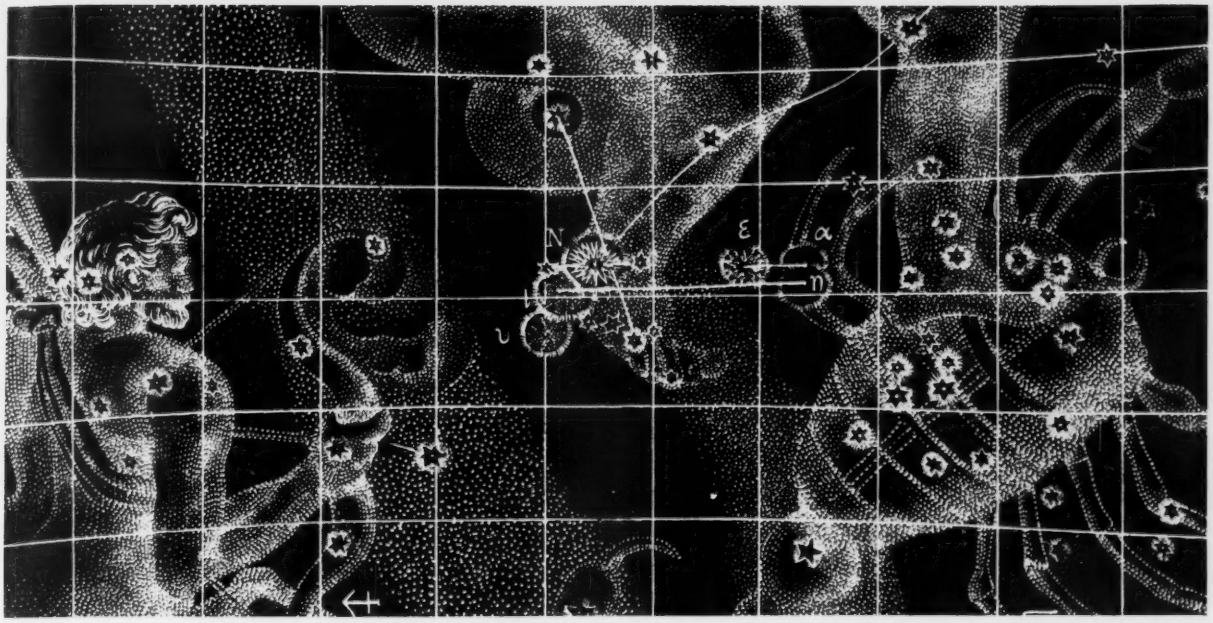
But it seems to this writer that the Magi, being familiar with the apparent movements of the heavenly bodies, would not regard so well-known and regular a visitor as Venus to be the sign they sought. Something more unusual is required.

At rare intervals two or three of the bright planets are seen very close together in the sky, and some observers have thought that a planetary conjunction might have been called a star by the ancients. Such an event occurred in December, 1946, when Venus and Jupiter were brilliant objects close together in the morning sky before sunrise; this spectacle, coming just at Christmas time, recalled to many the story of the Wise Men and the star.

A similar close approach of the planets Jupiter and Saturn happened in December, 1603, and was observed by Kepler, one of the great astronomers of the period just prior to the invention of the telescope. Some time later Mars became a part of the planetary configuration. Kepler was greatly impressed with this "triple conjunction" and wondered whether something similar could have been the



Before the star RR Pictoris became a nova in 1925, it was of apparent magnitude 12.7, a faint star in the field at the left. At maximum brightness it was magnitude 1.2, dominating its part of the sky. Its overexposed image is seen in the center picture, and at the right it has begun to fade back to obscurity.



Two of the suggested explanations are illustrated by Kepler's drawing published in 1606, partly reproduced here. The co-ordinate lines are five degrees apart. His own caption reads: "The open circles α and η show the places of Saturn and Jupiter, respectively, when they were in conjunction on December 17, 1603; ε, ι, and υ indicate the positions of Saturn, Jupiter, and Mars on October 10, 1604, the date that the new star [N] was first seen at Prague."

Wise Men's star. So he calculated the motions of these planets backward through the centuries and found that such a triple conjunction had indeed taken place in the year 6 B.C. But, as checks with planetarium projectors have shown, the sun was very near the planets and it is doubtful that the ancients actually observed the three planets at the time of their most compact formation. And the story mentions only a single star.

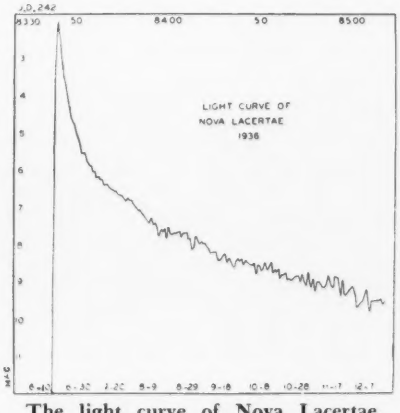
Other possibilities include comets and meteors. The latter may be dismissed as scarcely able to fulfill the conditions. A bright meteor or fireball is too transitory, only lasting a few seconds at most. Even the mistakes of translation and of handing the account down through the years would not allow one to say of a meteor that "it came and stood over where the young child was."

The appearance of a comet seems a possible explanation, especially as the ancients regarded comets as the forerunners of important events. A comet can be a prominent object in the sky for a few weeks, and one might have started the Wise Men off on their quest. Imagine the impression that would be made on them by a comet in the western sky with its tail extending upward (away from the sun) after sunset and seemingly pointing to a place beyond the horizon. It has been found that in 4 B.C. Chinese astronomers observed a comet bright enough to be seen in daylight! This comet appeared in the constellation Capricornus and remained visible for 70 days.

One other astronomical phenomenon could hold more promise than any other to explain the Star of Bethlehem. At unpredictable intervals a new star may appear in the sky, flaring up in a few days to a brilliancy that makes it quite prominent. Many of these "temporary" stars or *novae* never attain sufficient brightness to be seen without a telescope, but several times a century there is usually one that becomes bright enough to change the appearance of the constellation in which it occurs.

Most novae remain at peak brightness for only a few hours, and then they fade, rapidly at first, possibly with flareups during the next several months, and they gradually return to original insignificance.

Very occasionally—once in several centuries—there occurs a gigantic outburst of a star which astronomers call a *supernova*. When an event of this kind occurs in our own galaxy, the supernova for a time may outshine Venus at its brightest. Such an object appeared in the year 1572 and was thoroughly observed by Tycho Brahe, the famous Danish astronomer. The records he left concerning it are precise and reliable. The supernova occurred in the constellation of Cassiopeia, and was so bright it could be seen at noontime!



The light curve of Nova Lacertae, 1936, which was of magnitude 2.1 at maximum brightness.

Only 32 years later, in 1604, another supernova appeared, this time in Ophiuchus and observed by Kepler. Not as bright as Tycho's star, it nevertheless became a rival of Jupiter, and it appeared in the region of the triple conjunction of planets mentioned above. Kepler's chart of these happenings is reproduced here.

Another famous supernova of our galaxy is that of 1054, recorded by the Chinese and probably the event that caused formation of the Crab nebula in Taurus.

Since Kepler's star appeared, there have been no other supernovae in the Milky Way system, but telescopically we have seen them in a number of other galaxies, where the intrinsic brilliance of some may have exceeded even that of Tycho's star. As there are billions of galaxies, the total number of such outbursts in the universe must be high.

Although records at the time of Christ's birth contain no clues as to the occurrence of a nova or supernova, we must remember that the recording of scientific happenings was a chance affair in those days and that records, when made, risked serious distortion and loss over the centuries. To me it seems quite possible that the Wise Men's star was a nova, or even a supernova. But many readers may not agree with this speculation, preferring one of the other astronomical possibilities.

ASTRONOMICAL SCRAPBOOK

John Bevis and an Occultation of Mercury by Venus

ON THE NIGHT of January 9, 1591, young Johannes Kepler, then a student at the German university of Tübingen, went outdoors with his teacher Maestlin to observe a close conjunction of Jupiter and Mars. The two planets rose shortly after midnight, but the watchers saw no trace of Jupiter.

It appeared to them that the giant planet was hidden behind Mars, and the reddish color convinced them that the latter was indeed the nearer of the two planets. Taken at face value, this seems to be an observation of one of the rarest of all planetary phenomena—the occultation of one planet by another.

However, this pretelescopic observation may merely concern a close approach or appulse of the two planets, with their separation less than the resolving power of the eye. It is well known that the bright planets appear to the naked eye considerably larger than they are in actuality. Tycho Brahe estimated the diameter of Mars as 100 seconds of arc when it is one astronomical unit from the earth—this value is 10 times greater than the planet's actual diameter. Naked-eye testimony is not enough, unless backed by precise calculations of the planets' positions, a verification that is lacking in the above case of Mars and Jupiter.

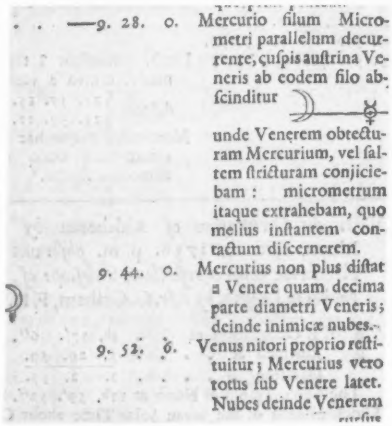
Only a solitary case is on record of the occultation of one planet by another having been observed telescopically. This was on May 28, 1737, when Venus passed in front of Mercury. On that morning at the Greenwich Observatory, John Bevis watched the event in broad daylight with a nonachromatic refractor of 24-foot focal length.

At 9:05 a.m. he saw the two planets only about three minutes of arc from each other in the field of view. They drew together rapidly, and by 9:40:03 Mercury was separated from Venus by 1/10 of the latter's diameter. Just then clouds came up, but at 9:48:09 Venus could be seen again in its full brilliance. Mercury was invisible, concealed behind the disk of Venus. Once more the clouds blotted out the spectacle, preventing further observations.

Bevis' unique record was critically analyzed more than a century later by the great French astronomer, Urbain Leverrier, who had begun his scientific career as an organic chemist but turned to celestial mechanics. Already director of the Paris Observatory and world-famed for his independent prediction of the planet Neptune, he had just completed his new and greatly improved tables of the motions of the inner planets. As one of the tests of these tables, he computed from them the circumstances of the 1737 occultation of Mercury by Venus.

For Bevis' 9:40:03 observation, Leverrier found the apparent diameters of Venus and Mercury to have been 52.42 and 6.82 seconds of arc, respectively. He computed the gap between them as 7.16 seconds, about 1/7 the diameter of Venus and in satisfactory agreement with Bevis' estimate of 1/10.

Mercury was indeed behind Venus at 9:48:09, but only partly occulted, having already emerged by 2.27 seconds of its diameter. However, Mercury was near elongation at the time, about "quarter-moon" phase, and the portion of its disk that protruded was unilluminated, so Bevis could not have seen it. Again Leverrier's calculations agreed with the description by Bevis, and the Paris astronomer commented with pride, "The precision with which the principal phases were observed in the occultation of Mercury by Venus on May 28, 1737, is a remarkable confirmation of the exactness of our tables of the sun, Mercury, and Venus."


—9. 28. 0. Mercurio filum Micrometri parallelum decurrente, cuſpis auſtrina Veneris ab eodem filo abſcinditur
unde Venerem obtecturam Mercurium, vel ſaltem ſtricturam conjiciebam: micrometrum itaque extrahebam, quo melius inſtantem contactum diſcernerem.
9. 44. 0. Mercurius non plus diſtat a Venere quam decima parte diametri Veneris; deinde inimicæ nubes.
9. 52. 0. Venus nitori proprio reſtituitur; Mercurius vero totus ſub Venere latet. Nubes deinde Venerem

John Bevis' two sketches show Mercury just before it was occulted by Venus. His report is reproduced in part from the "Philosophical Transactions," Vol. 41, Part 2, of 1740-41. The printed times are for a clock that was 3 minutes 57 seconds fast of Greenwich mean time.

Although he observed at Greenwich, John Bevis was an amateur astronomer. Born in 1695 at Old Sarum, in Wiltshire, England, he became a physician with wide scientific interests. Besides the astronomical observations that comprised most of his 27 papers in the *Philosophical Transactions*, he made pioneer electrical experiments. Bevis was also the inventor of a "satellite slide rule," for predicting eclipses of Jupiter's satellites.

In 1738 he erected a private observatory at Stoke Newington, where he began an ambitious project, the preparation of a great star atlas that was to contain many more stars than Bayer's, and to have greater exactness. To obtain star positions for this work he made such numerous meridian observations—often 160 stars in a single night—that his materials were complete by 1745. The final product was his *Uranometria Britannica*, an atlas in 50 sheets, to be accompanied by a catalogue of the star positions.

But this enthusiastic amateur became the victim of circumstances that robbed the world of his life's work and consigned him to an undeserved obscurity. Although the atlas was actually printed in 1750, it was never distributed owing to the bankruptcy of his publisher. The edition was lost, and surviving copies are exceedingly rare. Lalande, writing in 1792, seems to have known of only one copy, in the possession of Messier. The star catalogue was never published, and there is no trace even of its manuscript.

This double loss deprived the astronomical world of a useful tool which would have given its author lasting fame. At that time the lack of adequate star maps was a serious handicap to observers. For example, it greatly retarded the growth of variable star astronomy. The meridian observations of stars by Bevis, if of adequate quality, could have been of value for the later determination of proper motions.

John Bevis died at London on November 6, 1771. While he is nearly forgotten today, he deserves notice for his observation of a remarkable planetary phenomenon that may not recur for many centuries to come.

JOSEPH ASHBROOK

CALCIUM IN THE UPPER ATMOSPHERE OF THE EARTH

Two violet emission lines of ionized calcium have been detected in the spectrum of twilight by A. V. Jones, University of Saskatchewan. He used spectrographs with Schmidt-type optics, pointing to sky areas where the edge of the earth's shadow was 100 kilometers above the ground. The wave lengths and relative intensities of the lines corresponded to the *H* and *K* lines of ionized calcium, familiar as strong absorption features in the solar spectrum. They are absent in the night sky and aurora, and their occurrence seems to be a twilight phenomenon, but they are variable in intensity and sometimes not detectable. Dr. Jones suggests that the calcium vapor in the upper atmosphere may be of meteoric origin, as the lines were unusually strong at the time of the 1955 Perseid shower.

CORRECTION

In the October issue, page 545, second column, line 19 from the bottom should read: "19:00 UT (9:00 a.m. Hawaiian standard time)." Leo Mattersdorf, New York City, points out that the difference between the Greenwich meridian and the Hawaiian time zone is 10 hours, not 10½.

The First Determinations of Stellar Parallax--II

OTTO STRUVE, *Leuschner Observatory, University of California*

Born in Germany, Friedrich George Wilhelm Struve directed the Russian observatories at Dorpat (1820-38) and Poulkovo (1839-61). Modern double star astronomy began with him.

ONE of the most remarkable epochs in the history of astronomy came in the years 1837-39 when the first successful measurements of stellar distances were announced. F. W. Bessel, F. G. W. Struve, and Thomas Henderson all shared in this triple break-through, with their parallax determinations of 61 Cygni, Vega, and Alpha Centauri, respectively. But as we saw last month, there is much confusion in recent astronomical literature concerning the chronology of their contributions, and regarding the parts these three men played.

Actually, Wilhelm Struve published a parallax of Vega in 1837 that closely agrees with the modern value; Bessel announced his results in 1838; and while Henderson reported the parallax of Alpha Centauri in 1839, he had begun his observations before the other two. More significant than priority in time, however, is the share each of these three men had in convincing the world that stellar distances were indeed measurable after so many failures during the preceding centuries.

When the Copernican concept of the solar system appeared in the 16th century, it encountered a serious objection in Aristotle's old comment that if the earth were in orbital motion the position of each star would undergo a yearly oscillation. Since no such displacements had been detected, Aristotle had rejected the idea of a moving earth, and all of his later proponents, including Tycho Brahe, believed that the absence of a measurable parallax contradicted the Copernican hypothesis. The early astronomers were not prepared to place the stars remote enough to make stellar parallaxes too small to be detected by the means then available.

Despite this objection, the Copernican theory gradually gained ground and by the middle of the 17th century it was so well established that astronomers began to search systematically for the displacements predicted by the theory. One of the first of these attempts was made by Robert Hooke in London, during the year 1669.

He used a telescope mounted vertically in his house, with the objective firmly attached to the roof, and he attempted to measure accurately the departure from the vertical of the direction to a star passing near the zenith of London. This small angle would be expected to vary slightly through the year, and Hooke's intention was to find an annual periodicity of the kind required by the theory of parallax. He used the 2nd-magnitude star Gamma Draconis, but his observations were interrupted soon after their start by the accidental breaking of his telescope objective.

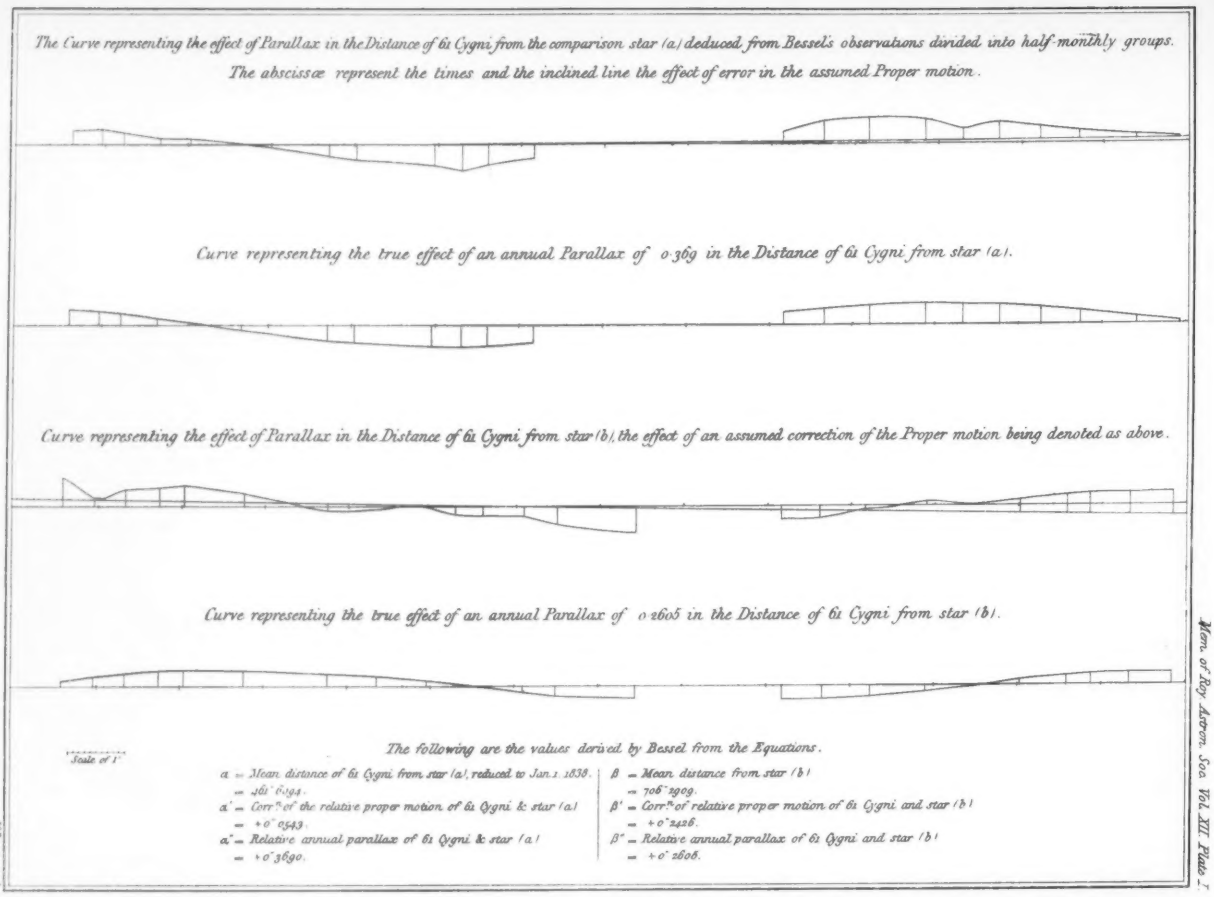
Later, in the years 1701 to 1704, Olaus Römer tried to measure the parallaxes of stars at his observatory in Copenhagen. He chose the bright stars Sirius and Vega, applying the method illustrated at the top of page 11 last month, for stars located in nearly opposite points of the sky as seen from the earth. Römer thought that he could actually detect a small annual change in the angle between the stars. In 1727 another Danish astronomer, C. Horrebow, recomputed Römer's data and announced in his book *Copernicus Triumphans* that the long-sought confirmation of the Copernican theory was finally provided. However, much later C. A. F. Peters demonstrated conclusively that the small angular change measured by Römer was in reality caused by his clock, whose rate was affected by the daily change of temperature in the observatory.

A few years after the work of Römer, an amateur astronomer named Samuel Molyneux started a new series of observations of Gamma Draconis at his private observatory near London. His method was essentially that of Hooke. With the help of his friend James Bradley, of Oxford, he found in 1725-26 that the position of this star actually underwent displacements that mirrored on the celestial sphere the orbital motion of the earth. Encouraged by this result, Bradley began to observe a second star, 35 Camelopardalis, and soon found a conspicuous annual motion in the form of an ellipse.

The German astronomer Friedrich Wilhelm Bessel (1784-1846) was director of the Königsberg Observatory when he measured 61 Cygni. He revolutionized positional astronomy.

Both stars, however, failed to conform to the demands of the theory of stellar parallax. In the case of Gamma Draconis, Bradley expected to find a maximum departure from the vertical in June and a minimum departure in December, with average values in March and September. But the observations showed the angle to be greatest in September and least in March, with average values in June and December.

To explain this strange behavior, in 1728 Bradley announced the principle of the aberration of starlight. A small shift takes place in the direction from which a star's light appears to be coming. This shift is always in a forward sense with respect to the earth's motion around the sun, and its amount depends on the vector sum of the velocity of the earth and the velocity of light, as explained on page


The Curve representing the effect of Parallax in the Distance of 61 Cygni from the comparison star (a) deduced from Bessel's observations divided into half-monthly groups.
The abscissæ represent the times and the inclined line the effect of error in the assumed Proper motion.
Curve representing the true effect of an annual Parallax of 0·369 in the Distance of 61 Cygni from star (a).
Curve representing the effect of Parallax in the Distance of 61 Cygni from star (b), the effect of an assumed correction of the Proper motion being denoted as above.
Curve representing the true effect of an annual Parallax of 0·2605 in the Distance of 61 Cygni from star (b).
Scale of 1"
The following are the values derived by Bessel from the Equations.
α = Mean distance of 61 Cygni from star (a), reduced to Jan.1 1838. = 451° 6·194.
α' = Corr.n of the relative proper motion of 61 Cygni & star (a) = +0"·0543.
α" = Relative annual parallax of 61 Cygni & star (a) = +0"·3690.
β = Mean distance from star (b) = 706°·2909.
β' = Corr.n of relative proper motion of 61 Cygni and star (b) = +0"·2426.
β" = Relative annual parallax of 61 Cygni and star (b) = +0"·2605.
Mem. of Roy. Astron. Soc. Vol. XII. Plate 1.

The first and third curves are Main's plots of Bessel's observed shifts of 61 Cygni with respect to comparison stars "a" and "b." The second and fourth curves are their predicted counterparts. Compare these curves with those of Wilhelm Struve for Vega, on the opposite page. From the "Memoirs" of the Royal Astronomical Society.

12 in the November issue. The shift is the angle of aberration and has nothing to do with the angle of parallax.

A significant difference should be noted. The aberrational ellipses are independent of the distances of the stars, being always about 41 seconds of arc in length. On the other hand, for example, members of an optical double star whose distances from the sun differ by a factor of 10 have parallactic ellipses with dimensions in the ratio of 10 to 1.

Bradley's observations were accurate enough to show that the aberrational ellipse of Gamma Draconis was not complicated by a parallactic shift of more than one second of arc in amplitude. This evidence placed the average naked-eye star at least 200,000 astronomical units distant (200,000 times the sun's distance).

There the matter rested until the beginning of the 19th century. In 1805, however, Giuseppi Piazzi at Palermo published parallaxes between 2 and 10 seconds of arc for Aldebaran, Procyon, Sirius, and Vega. Although he mistrusted some of these results, he regarded as probable his value of 4" for Sirius. His parallax of 2" for Vega was soon exceeded by Calandrelli's measurement at Rome of 4".4. Brinkley in Dublin found 1".1 for Vega and 2".75 for Altair. These large values were strongly criticized by John Pond, at Greenwich, whose measurements indicated only that the parallaxes of most of these stars were much smaller than one second of arc.

Bessel entered the picture about 1812, with a discussion of Bradley's transit observations. This gave 0".044 ± 0".243 for the sum of the parallaxes of Sirius and Vega, and 0".931 ± 0".208 as the sum for Procyon and Altair. In all cases, the individual parallaxes were evidently much less than one second of arc, but the probable errors were still too large and masked the actual numerical values.

About the same time, W. Struve obtained, from his own observations of 17 pairs of stars, an average value of 0".052 ± 0".017 for the parallax of an individual star, according to Peters' recomputation of his data. W. Struve had ingeniously modified Römer's method to gain greatly increased accuracy. With a transit instrument he determined the difference between the right ascensions of a pair of stars, one crossing the meridian below the pole, the other above, within a few minutes of each other. In this way, his observations were essentially independent of the rate of his clock. The average parallax was only 1/20 second of arc, and agreed with Bessel's and Pond's results, while strongly contradicting those of Piazzi, Calandrelli, and Brinkley cited above.

Even more convincing was Struve's discussion of the hypothetical parallaxes of seven visual binary stars, in his 1837 book *Mensurae Micrometricae*, using a principle still employed today. It is based on the fact that Kepler's third law of orbital motion may be applied to binary star systems by the following formula:

$$\pi\ (M_1 + M_2)^{1/3} = a/P^{2/3},$$

where M_1 and M_2 are the masses of the component stars in terms of the sun; a is the observed semimajor axis of the relative orbit, in seconds of arc; P is the period of revolution in years; and π is the parallax.

All the unknown values are on the left and the observed quantities on the right-hand side of the equation. Thus Struve obtained for each binary the product of its parallax times the cube root of its total mass. His values (in seconds of arc) are given in Column 1 of the table on the next page.

In any individual case, the total mass of the binary is unknown beforehand, but

it may be estimated statistically for a group of stars. We *now* know that it is reasonable to adopt $M_1 + M_2 = 3$ solar masses as an average. The cube root of 3 is about 1.44. Hence Struve's hypothetical parallaxes would have been about 50 per cent smaller than those listed, had he been able to apply this factor, as we have done in Column 2 of the table.

Star	*1*	*2*	*3*
Gamma Virginis	0.185	0.128	0.101
Castor	0.200	0.139	0.072
Sigma Coronae Borealis	0.085	0.059	0.047
Xi Ursae Majoris	0.147	0.102	0.127
70 Ophiuchi	0.236	0.164	0.188
Zeta Herculis	0.172	0.120	0.110
61 Cygni	0.254	0.176	0.292

The best modern trigonometric parallaxes observed for these stars, in Column 3, are in quite remarkable agreement with Column 2, in most cases. Nevertheless, this work of Struve's was not a solution of the parallax problem, because in 1837 the masses of the stars were unknown.

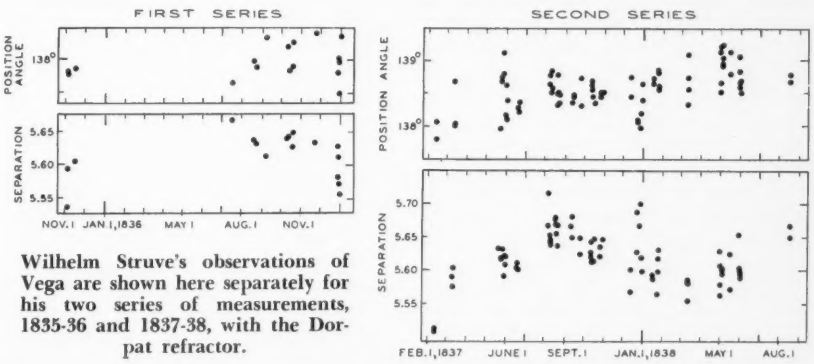
The direct parallax measurements of 61 Cygni by Bessel[10] and those of Alpha Centauri by Henderson[11] were fully discussed by Robert Main in the *Memoirs* of the Royal Astronomical Society in 1840. Shown opposite is Main's illustration of the plotted results of Bessel's observations, with time as the abscissa and departure of 61 Cygni from its mean position (with reference to each of two comparison stars) as the ordinate. The observed curves agreed so well with the predicted ones that there remained no doubt of the reality of this parallax.

Main also discussed Struve's observations of Vega; although the correspondence between the observed and theoretical curves was less satisfactory than in Bessel's work, Main concluded that the parallax was real. But Main's analysis concerns the observations from August 16, 1836, to August 18, 1838, whereas Struve's first announcement in 1837 referred only to observations made between November 3, 1835, and December 31, 1836. Main has not answered the question: Was there already in this first series a reliable indication of a measurable parallax?

This is the crucial question discussed in the recent article by Deitch from which we quoted last month. From his own recomputation, Deitch concludes that the parallax of Vega was indeed shown by the 1835-36 measurements. Moreover, from the entire material of 1835 to 1838 Deitch obtains as the final result 0″.113 ± 0″.018, a value that is close to the best modern determination of Vega's parallax.

Struve's own appraisal was more modest, as shown by Jackson's translation of the Latin text in *Mensurae Micrometricae:*

"As for the parallax, we have found $\pi = +0''.125$ with a probable error of 0″.055. We can therefore conclude that the parallax is very small, as it probably lies between 0″.07 and 0″.18. But, indeed, we cannot give it yet absolutely. However, a continuation of the observations, if all are made at the epoch of maximum displacement, will draw still closer the limits of uncertainty; whence it appears indubitable that stellar parallaxes which are not less than 0″.1 can be detected by our instrument by the method we have given."



Wilhelm Struve's observations of Vega are shown here separately for his two series of measurements, 1835-36 and 1837-38, with the Dorpat refractor.

Bessel's opinion was given in his article on 61 Cygni: "Because of this good beginning, Struve hopes that he can ascertain the parallax of α Lyrae within very narrow limits—a hope which I believe well founded. It is already clear that these observations support Pond, and contradict the much larger parallax by Brinkley for this same star."

And in a letter to Olbers, dated October 18, 1837, Bessel wrote, "I think Struve has taken the lead, for he has made an attempt which, though not as yet a complete success, nevertheless seems to offer good prospects."

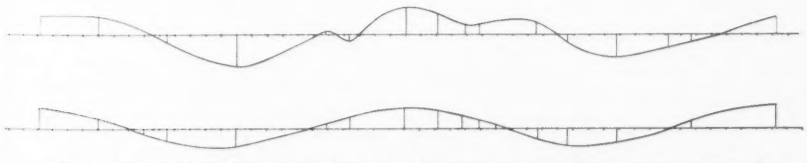
This estimate agrees essentially with Struve's own, and with that of his son Otto, who wrote in 1895[12], "With this instrument [the new 9-inch refractor at Dorpat] he finally made the first successful attempt to measure the distance of a star (α Lyrae) from the solar system, or at least to fix the distance within narrow limits."

To help the reader form an independent opinion, we have plotted Struve's observations, uncorrected for the proper motion of Vega with respect to the optical companion star (Main's plots are the corrected distances). There is no obvious annual periodicity in the position angles, and there are excellent reasons for disregarding them—as was already explained in Struve's two memoirs. But the separations in the second, longer series show the distinct annual trend—there is a maximum near the theoretical maximum of August 15th, and a minimum not far from the predicted time, about the middle of February.

The earlier series, taken alone, does not suffice to demonstrate this annual periodicity, but when compared with corresponding seasons of the second series, the decrease in separation from July, 1836, to January, 1837, is definite enough. Nevertheless, standing alone, this indication of a parallax effect in the earlier series would not justify a more optimistic view than the one expressed by Bessel.

Struve himself explained the discordance between his 1837 and 1839 parallaxes for Vega as due to accidental errors of the observations. Deitch accepts this explanation, commenting that small systematic errors existed in the distances, as well as in the position angles. Perhaps Struve's preoccupation with building and organizing the Poulkovo Observatory may have prevented him from devoting his full attention to Vega.

Both Bessel and Struve had proven before 1837 that the large parallaxes found by other astronomers were spurious. Both persisted in their efforts to find a measurable parallax, aided by two excellent Fraunhofer instruments, the Königsberg heliometer and the Dorpat refractor. To Struve belongs the credit for having found the first trace of a real parallax of the order of 0.1 or 0.2 second of arc and of having thereby inspired Bessel to continue his work on 61 Cygni. In 1840, Main wrote, "Struve's parallax of α Lyrae



Above, the parallactic shift of Vega as observed by Wilhelm Struve; below, the predicted shift for a parallax of 0″.261. The general agreement of these curves, drawn by Robert Main in 1840, shows that Struve's observations of 1836-38 actually revealed the parallax of Vega. From the "Memoirs" of the Royal Astronomical Society, Vol. 12.

is that which, as Bessel modestly acknowledges, excited his ambition to obtain a similar result."

Bessel reached a precision previously unsurpassed, and to him, without doubt, goes the credit for producing the first fully convincing determination of a star's distance, in 1838. The parallax of 61 Cygni is nearly three times as large as that of Vega, but the stars were on the observing lists of both astronomers, and Bessel had previously observed Vega without obtaining a measurable effect. We know today that 61 Cygni, with its large proper motion and measurable orbital motion, was a more promising choice than Vega, with its high luminosity and small proper motion. But 120 years ago the very basis of such knowledge—the stellar parallaxes—was lacking, and Bessel's choice was a happy intuition.

Henderson's observations of Alpha Centauri, the most promising star of the three, were made at the Cape of Good Hope from April, 1832, to May, 1833, whereas Struve began work on Vega in 1835 and Bessel on 61 Cygni in 1837. Yet it was Bessel who called Henderson's attention to the favorable characteristics of Alpha Centauri. But Henderson's instrument was a mural circle (see page 10 last month), of the same construction as other mural circles that had failed time after time to give reliable parallaxes. Henderson was therefore not prepared to discuss and publish his results until after the positive parallaxes of 61 Cygni and Vega had become known.

It is of some historic interest that, among the memories transmitted to me by my family, the brightest was the high recognition accorded to Bessel by my great-grandfather, Wilhelm Struve. There was never any quarrel between these two astronomers, and they maintained the closest bonds of friendship until the death of Bessel in 1846. W. Struve never made any claims other than those I have quoted, and I believe that some of the more recent claims on his behalf by others are exaggerated. It is difficult to find fault with those accounts that attribute to Bessel the first determination of a fully convincing stellar parallax.

In my personal opinion, Struve's principal contribution was made in the field of double stars, and it was for this he received the Royal Astronomical Society's gold medal in 1826. He and Henderson, however, share with Bessel the credit for having brought about the change in distance scale mentioned in the beginning of the first installment of this article.

NOTES

10. *Astronomische Nachrichten, 16,* 66, 1838; see also Bessel's letter to von Busch, dated October 10, 1838, presented to the Royal Academy of Sciences in Berlin; also *Monthly Notices* of the Royal Astronomical Society, *4,* No. 17, 1838.
11. *Memoirs* of the Royal Astronomical Society, *11,* 61, 1839.
12. *Wilhelm Struve,* Otto Struve, Karlsruhe, 1895, page 38.

NEWS NOTES

SEARCH FOR AN ATMOSPHERE ON THE MOON

The most delicate tests yet applied show that at the moon's surface the lunar atmosphere must be less than 10^9 times as dense as the earth's, according to Audouin Dollfus, of Meudon Observatory in France. His observations are detailed in *Annales d'Astrophysique, 19,* 71, 1956.

Even a very tenuous gaseous envelope should produce faint extensions of the cusps of the crescent moon near first and last quarter, and this lunar twilight should be completely polarized. Using extreme care to minimize scattered light, Dr. Dollfus photographed the moon with the coronagraph of the Pic du Midi Observatory, but prolonged exposures showed no effect of this kind.

In a more sensitive test, a polarimeter attached to the coronagraph revealed no trace of the expected polarization, indicating that if a permanent lunar atmosphere exists it cannot contain more than 10^{10} molecules per cubic centimeter, compared with more than 10^{19} in terrestrial air at sea level.

THE CLOUDS OF VENUS

The composition of the cloud veil surrounding the planet Venus has long been controversial. Now E. J. Opik, Armagh Observatory, North Ireland, suggests that the clouds contain "great amounts of dust, ground off the rocky surface of the planet." The chief evidence is that photometric measurements show the cloud veil is distinctly yellow; if the clouds were of water they should be white.

Dr. Opik objects to the proposal by D. H. Menzel and F. L. Whipple (*Sky and Telescope,* November, 1954, page 20) that the clouds are water, and that the low temperature of the cloud surface would prevent detection of water vapor in Venus' atmosphere. The Armagh astronomer believes that the temperature measurements should be reinterpreted, on the basis that Venus does not radiate as a black body. Instead of the very low temperature of −39° centigrade recently adopted, he suggests that about +44° centigrade is more likely. But this value, which Dr. Opik gives in the *Irish Astronomical Journal,* rests on some uncertain assumptions.

IN THE CURRENT JOURNALS

A NATIONAL RADIO OBSERVATORY, by Bart J. Bok, *Scientific American,* October, 1956. "The U. S., where radio astronomy had its birth, has hitherto lagged behind other countries in facilities for the pursuit of this fascinating science. But it will soon have one of the world's largest and finest radio telescopes."

SOLAR FURNACE IN HIGH-TEMPERATURE RESEARCH, by Tibor S. Laszlo, *Science,* October 26, 1956. "There is, however, one application in which solar energy is superior to any other form of energy presently available, namely in the field of high-temperature research."

ASTEROIDS IN 1957

A bird's-eye view of the current state of an active branch of astronomy is afforded by the recently published *Ephemerides of Minor Planets for 1957.* Under international agreement, this volume is prepared each year by the Institute for Theoretical Astronomy, in Leningrad. It contains finding ephemerides for 1,266 asteroids that will come to opposition in the year 1957, calculated by astronomers in Germany, Russia, United States, Spain, and China.

In this volume, the list of numbered asteroids reaches 1,616; this total is growing more slowly than before the war, because of the present policy of assigning numbers to new minor planets only after they have been observed in two or more oppositions. Many of the recent discoveries are very faint objects; an extreme case is 1580 Betulia, which will be of magnitude 19.8 when it reaches opposition next November 3rd.

SUPERNOVA LIGHT CURVES AND CALIFORNIUM 254

A remarkable property of supernovae of type I—exploding stars like Tycho's in 1572, Kepler's in 1604, and that of 1054 which blew apart to form the Crab nebula —is the very uniform slow decline in brightness that sets in two or three months after maximum light. In all well-observed type-I supernovae the rate of this decline is the same, about 0.0137 magnitude per day. This would result if such stars, during this stage, shone primarily by energy liberated by a radioactive element with a half-life of 55 days.

This element is now identified as californium of atomic mass 254, according to astronomers G. R. Burbidge and F. Hoyle, at Mount Wilson and Palomar Observatories, and physicists Mrs. E. M. Burbidge, R. F. Christie, and W. A. Fowler, of the California Institute of Technology.

Californium 254 was produced artificially during the November, 1952, Bikini thermonuclear test by subjecting uranium to an intense beam of neutrons. It was found to decay by spontaneous fission with a half-life of 55 days. Both theory and experiment indicate that this is the only atomic nucleus with a half-life of this length that decays by the energetic fission process rather than by the low-energy emission of alpha particles.

The authors of the suggestion point out that conditions inside a star at the

brink of a supernova explosion are favorable for the production of californium 254 from lighter atoms by neutron addition. The source of the abundant neutrons required would probably be mostly iron.

The California scientists have detailed their hypothesis in two articles, in the *Publications* of the Astronomical Society of the Pacific and in the *Physical Review*.

LONG STELLAR ECLIPSES

The little-known variable star AZ Cassiopeiae has turned out to be an eclipsing variable with the unusually long period of 9.3 years. Dr. Alice Farnsworth had noted that the spectrum was composite, *OB* + *M*0.[1] Five eclipses, the earliest in 1901, were found on Harvard Observatory patrol camera photographs by Dr. Joseph Ashbrook. When the larger red star eclipses the smaller blue one, the magnitude drops from about 11.0 photographic to about 12.0. This change takes 10 days, followed by 92 days of total eclipse and then 10 days for recovery to maximum light.

The next eclipse begins on the 26th of this month, with totality from about January 5th to April 7th, and the end of eclipse on April 17, 1957. The position of this variable is $1^h\ 37^m\ 50^s$, $+61°\ 10'.2$ (1950); it has practically the same declination as a 6th-magnitude star whose right ascension is 41 seconds of time greater.

AMERICAN ROCKET PROGRAM FOR THE IGY

During the 1957-58 International Geophysical Year, American scientists may launch as many as 200 rockets for upper-atmosphere research, according to Homer E. Newell, Jr., Naval Research Laboratory. Dr. Newell, of the U. S. National Committee's technical panel on rocketry, reported details of American plans on September 11th to the IGY meeting at Barcelona, Spain.

He told delegates from more than 50 nations that the number of flights for each group of experiments would be approximately: atmospheric structure, 60 rockets; upper-air winds, 18; solar ultraviolet and X-ray radiation, 74; airglow (light emission of the night sky), 4; aurora, 115; electrical properties of the ionosphere, 19; chemical composition of the upper atmosphere, 10; earth's magnetic field, 95; and cosmic rays, 57 rockets.

Since many rockets will carry several experiments, the total of these numbers is much more than the expected number of launchings. To widen the geographical coverage of the experiments, rocket firings are planned in New Mexico, at Ft. Churchill in northern Canada, in the Arctic and Pacific Oceans, and from Antarctica. The programs of other nations will further broaden this distribution.

Ft. Churchill is a location of particular importance, because of its nearness to the north magnetic pole. Through the cooperation of the Canadian government, many types of geophysical observations will be made there to supplement the rocket data.

Dr. Newell reported that tests of the rockets to be used for the IGY program were encouraging. At White Sands Proving Ground, an Aerobee-Hi rocket has been flown successfully to a height of 164 miles, assuring a high-altitude version of the Aerobee for IGY projects. There have also been a number of successful trials of two-stage rockets, with a Nike booster as the first stage and either a Deacon or a Cajun for the second. The second stage can carry a payload of 25 to 50 pounds into the ionosphere.

In other tests, 10 Rockoons have been fired from shipboard in the Pacific, about 400 miles off the California coast. They carried instruments for measuring the sun's radiation and X-rays during a solar flare. Also in this project, a Skyhook balloon was sent aloft carrying a Deacon rocket. When a solar flare was observed either at the High Altitude Observatory, Climax, Colo., or the Sacramento Peak Observatory, Sunspot, N. M., this fact was communicated to the ship, and the Deacon was fired by radio command from the ship. This method allows prompter study than is possible with a conventional ground-launched rocket, for a solar flare often lasts only a few minutes. The balloon is maintained at a height of about 80,000 feet, from which the rocket ascends to 60 or 70 miles within 90 to 120 seconds.

MESSIER 11

Just visible to the unaided eye in the constellation Scutum, the open star cluster M11 is a very rich grouping that appears superimposed on the Scutum star cloud. The magnitudes and colors of about 400 stars in this cluster have recently been studied by H. L. Johnson, Lowell Observatory, and A. R. Sandage and H. D. Wahlquist, Mount Wilson and Palomar Observatories. Their discussion appeared in the *Astrophysical Journal*.

They first determined magnitudes and colors for 40 stars in the cluster, using a photoelectric photometer on the 82-inch McDonald Observatory reflector. These stars were then employed as standards to derive yellow, blue, and ultraviolet magnitudes for the other stars, from photographs taken with the 100-inch telescope at Mount Wilson.

In this way a color-magnitude diagram for the stars in M11 could be plotted. The location of the main sequence in this diagram gave the distance of the cluster as 1,660 parsecs (5,400 light-years), after allowance was made for interstellar absorption.

No main-sequence stars were found that were brighter than about visual absolute magnitude −1.0, indicating that the cluster is a relatively young one, on the basis of current theories of stellar evolution. Another feature, unusual among open clusters, is the presence of numerous yellow giant stars with this same luminosity, about one magnitude brighter than expected. This fact is another indication of the comparative youth of M11, which appears to be intermediate in age between the Pleiades and Praesepe.

MARS AND LAODAMIA

Close approaches of asteroids to principal planets are uncommon events, but in September, 1957, the minor planet 1011 Laodamia will pass within 10 million miles of Mars, according to E. Rabe, University of Cincinnati Observatory. At that time, the magnitude of Laodamia will be 15 or 16. If this object is well observed before and after the encounter, it should be possible to determine the mass of Mars accurately, from the perturbations its attraction produces in the motion of the asteroid.

The orbit of Laodamia is markedly elliptical, and its distance from the sun ranges from 145 to 300 million miles during its 3.7-year period of revolution. Near approaches to Mars can occur only when the asteroid is close to the perihelion point of its orbit.

ASTRONOMERS TO MEET IN NEW YORK CITY

During Christmas week the American Astronomical Society will hold its 96th meeting at the American Museum-Hayden Planetarium, New York City, jointly with Section D of the American Association for the Advancement of Science. The program will feature a symposium, "The Recent Close Approach of Mars," on Friday, December 28th.

The sessions for papers are to be held at the Roosevelt lecture hall, beginning on the morning of December 27th. In the afternoon, the Helen B. Warner lecture will be given by Harold Johnson, of Lowell Observatory, and at the banquet that evening Dr. Seth B. Nicholson, Mount Wilson and Palomar Observatories, will give the address of the retiring vice-president of Section D, on "The Solar Cycle." The program closes on Saturday, December 29th, with morning and afternoon sessions for papers.

AMERICAN OPTICAL ACQUIRES J. W. FECKER, INC.

One of America's oldest astronomical instrument manufacturers, J. W. Fecker, Inc., has been taken over as a wholly owned subsidiary by the American Optical Company. There will be no change in the Fecker products or personnel, and Joseph Kalla will continue as president of the Pittsburgh organization.

The company was founded in 1881 by John A. Brashear, famous as an amateur astronomer and telescope maker; later it was operated by J. B. McDowell; and in 1926 was taken over by the late J. W. Fecker, who died in 1945.

Amateur Astronomers

The 45th Meeting of the AAVSO

FOR THE SECOND YEAR in succession, the American Association of Variable Star Observers met in Springfield, Massachusetts, at the Springfield Museum of Natural History.

On Friday evening, October 19th, Dr. Harlow Shapley, former director of Harvard Observatory and at present Neilson professor at Smith College, spoke on the latest developments in the study of galaxies. When asked about life on other planets, he suggested that there are in the universe at least 100 million planets with biochemical evolution similar to the earth's. After the lecture, we attended a special demonstration of the Seymour planetarium projector by its designer and builder, Frank D. Korkosz.

The business meeting centered around committee reports, the election of 30 new annual members and two sustaining members, and an amendment to the constitution changing the 25-year-old title of recorder to director, the latter indicating more clearly the present duties of the office. Percy W. Witherell was cited for his work as treasurer of the association for 25 years.

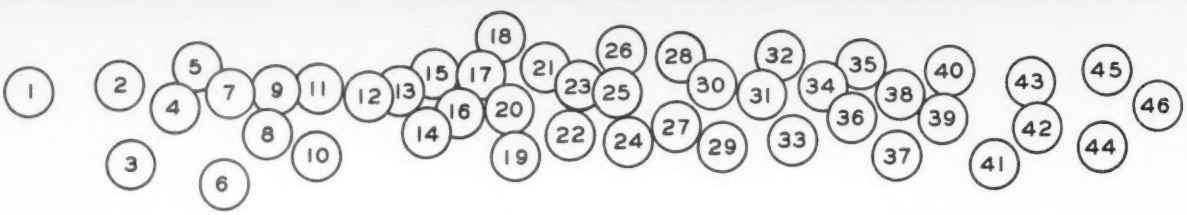
September 30, 1956, ended a year in which 49,579 observations of variable stars were made by 131 observers in 19 countries. Three observers spent a total of 33 hours and 43 minutes in constant watch of eight flare stars. No flares were seen, but the negative reports are of statistical value. For the third consecutive year, the most active observers were R. P. de Kock, of South Africa, with 5,699 estimates, and Edward Oravec, Tuckahoe, N. Y., with 5,019.

The retiring chairman of the occultation program, Mrs. Margaret H. Beardsley, said that she is handing a very active group of observers over to the new chairman, Dr. Sarah J. Hill, at Wellesley's Whitin Observatory. The Solar Division, under the chairmanship of Harry L. Bondy, continues to provide the American sunspot numbers to the National Bureau of Standards, and carries on many special projects. Lewis J. Boss, chairman of the photoelectric photometer committee, told of their brochure containing wiring diagrams and practical instructions for the use of photometers. The nova search committee is continuing its work under George Diedrich.

In the session for papers, Leith Holloway said that his prediction at our spring meeting of the maximum of sunspot activity does not appear to need revising. He predicted a maximum American number of 196, occurring at the end of the first quarter of 1957. Ralph Buckstaff led a discussion about counting groups of sunspots.

John Gausted gave a talk on white dwarf stars, from the discovery of the companion of Sirius through the recent work by W. J. Luyten, who computes that about three per cent of all stars are white dwarfs.

Other papers were by George Lovi, on a star suspected to have a large proper



The 45th meeting of the American Association of Variable Star Observers, October 19-21, 1956. Photograph by R. W. Dunn.

KEY TO PHOTOGRAPH

1. Kenneth Weitzenhoffer, New York, N. Y.
2. John Gaustad, Minneapolis, Minn.
3. Ralph Wright, Worcester, Mass.
4. Leith Holloway, Washington, D. C.
5. Edward Oravec, Tuckahoe, N. Y.
6. Mrs. Curtis Williams, Hopatcong, N. J.
7. Edward De Gennaro, New York, N. Y.
8. Mrs. Alice Ford, Suffield, Conn.
9. Francis Reynolds, Potsdam, N. Y.
10. Curtis Williams, Hopatcong, N. J.
11. Mrs. Bernice Wray, Assonet, Mass.
12. William Cleaver, New Haven, Conn.
13. Herbert Luft, Elmhurst, N. Y.
14. Richard Hamilton, Darien, Conn.
15. John Thomas, DeGrasse, N. Y.
16. Alice Farnsworth, South Hadley, Mass.
17. David Rosebrugh, Meriden, Conn.
18. Newton Mayall, Cambridge, Mass.
19. Percy Witherell, Jamaica Plain, Mass.
20. Mrs. Herbert Luft, Elmhurst, N. Y.
21. Mrs. Virginia Nail, Cambridge, Mass.
22. Florence Rosenblatt, Brooklyn, N. Y.
23. Mrs. Marion Rosebrugh, Meriden, Conn.
24. Clinton Ford, Suffield, Conn.
25. George Diedrich, Elyria, Ohio
26. Jocelyn Gill, South Hadley, Mass.
27. Mrs. DeLorne Diedrich, Elyria, Ohio
28. Mrs. Margaret Beardsley, Springfield, Vt.
29. Leo Otis, Springfield, Mass.
30. Mrs. Walter Reeves, Portland, Me.
31. John Patterson, Boston, Mass.
32. John Welch, West Springfield, Mass.
33. Walter Reeves, Portland, Me.
34. Ralph Buckstaff, Oshkosh, Wisc.
35. James Wesling, Parsippany, N. J.
36. Cyrus Fernald, Wilton, Me.
37. Mrs. Margaret Mayall, Cambridge, Mass.
38. Mrs. Ralph Buckstaff, Oshkosh, Wisc.
39. Mrs. Emily Fernald, Wilton, Me.
40. P. Parker, Griffin, Ga.
41. Helen Stephansky, Jamaica Plain, Mass.
42. Betty Dodd, Boston, Mass.
43. Mrs. Hazel Miller, Glen Rock, N. J.
44. Mrs. P. Parker, Griffin, Ga.
45. William Miller, Glen Rock, N. J.
46. Dorrit Hoffleit, New Haven, Conn.

motion, and Edward Majden, on Perseid observations in Saskatchewan in 1956. Over 2,000 meteors were recorded, and 25 hours of exposure time yielded two direct meteor photographs and one meteor spectrum of good quality. William G. Cleaver described the geometry of lunar occultations; visual methods of observing these phenomena are by no means obsolete, and amateurs are urged to take part in the AAVSO occultation program.

At the banquet Saturday evening, Dr. Shapley presented his traditional annual highlights of astronomy. He noted the completion of two great long-term projects, Milton Humason's study of the radial velocities of several hundred galaxies, and the University of Michigan's publication of the results of 24 years work on southern visual double stars, during which R. A. Rossiter discovered more than 5,000 new pairs. Other highlights were the discovery of the antiproton; the planning for a large interinstitutional observatory; detection of red shifts in the radio spectra of distant galaxies; a convincing theory to account for the formation of heavy elements in stellar interiors; the dedication and operation of Harvard's 60-foot radio telescope for the study of the spiral arms of our galaxy; observation of Mars during its near approach; disclosure of Canadian project JANET, which uses the ionized trains of meteors for transmission of radio messages; two special conferences, one on the stellar distance scale, the other on precision instruments for measuring faint starlight; and the world-wide organization of amateur astronomers for visual tracking of the artificial satellite.

The meeting closed with a visit to John Welch's home and observatory on Saturday evening, and on Sunday morning we visited the Williston Observatory, Mt. Holyoke College, one of the best-equipped teaching observatories in the country.

Association officers for the coming year are Richard W. Hamilton, president; Mr. Buckstaff, 1st vice-president; Walter P. Reeves, 2nd vice-president; Clinton B. Ford, secretary; and Mr. Witherell, treasurer.

MARGARET W. MAYALL
Director, AAVSO

SPRINGDALE, PENNSYLVANIA

Since its organization in July, 1955, the Allegheny Valley A.A.A. has grown to 14 active members, and now has plans to sponsor a junior group. The club meets twice monthly at the Springdale Community Center. Its members have 10 telescopes, ranging from 2.4-inch refractors to a 12½-inch Cassegrainian reflector built by two brothers. During the close opposition of Mars, the group set up a systematic observing schedule.

Officers of the club are: Richard Butler, president; Robert Somerville, vice-president; William Hartmann, secretary; and Richard McLaughlin, treasurer. William Stocks, 215 Carson St., Springdale, is chairman of the society and may be contacted for further information.

THIS MONTH'S MEETINGS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Dec. 14, Dr. K. A. Strand, Dearborn Observatory, "Weighing the Stars."

Louisville, Ky.: Louisville Astronomical Society, 8:30 p.m., University of Louisville, Natural Science building. Dec. 4, Dr. Donald M. Bennett, University of Louisville, "The International Geophysical Year."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Dec. 5, Dr. Robert I. Wolff, College of the City of New York, "International Co-operation in Science."

Oakland, Calif.: Eastbay Astronomical Society, 8 p.m., Chabot Observatory. Dec. 1, William Livingstone, "The TV Telescope."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Dec. 1, Dr. Sarah L. Lippincott, Sproul Observatory, "Observations of the Sun."

ATLANTA ASTRONOMERS DISCONTINUE PUBLICATION

With its September, 1956, issue (Vol. IX, No. 3), the *Atlanta Astronomers' Report* has suspended publication. As responsibility for its production rested on only a few members of the Atlanta Astronomy Club, who have other pressing duties, there was difficulty in maintaining the high quality of content and manufacture of this excellent mimeographed journal.

Regular readers will miss the intriguing cover drawings by William Close, as well as the feature articles and detailed news reports.

CANADIAN TIME SIGNALS

Observers in the United States may wish to use Canadian time signals in timing astronomical observations. From Malcolm M. Thomson, of the positional astronomy division, Dominion Observatory, Ottawa, we learn that the Canadian time signals are broadcast over Station CHU at frequencies of 3,330, 7,335, and 14,670 kilocycles. They can be received over most of the North American continent and, with somewhat less certainty, in both Europe and Australia.

The time signals are broadcast on a 24-hour basis with voice announcements between the 50th and 60th seconds of each minute. The beginnings of the beats mark the exact seconds, and are reliable to a few hundredths of a second of true time. Seconds beats omitted are the 29th, so each half minute may be identified, and the 51st to 59th inclusive. During the first minute of each hour, the call "CHU Canada CHU" is sent in Morse code in place of the seconds.

Those who wish the correct time, but who do not have short-wave receivers, may listen once a day to any of more than 60 Canadian Broadcasting Corporation stations, which transmit signals at 1:00 p.m. Eastern time (standard or daylight, whichever prevails at Ottawa). Seconds beats commence at 40 seconds before the hour and continue to the hour. Ordinary time announcements by radio stations are not accurate enough for astronomical observations.

LAGUNA BEACH, CALIFORNIA

The Laguna Beach Astronomy Club, which was organized last spring, has about 20 junior and senior members. We meet on the second and fourth Thursday evenings of the month at different homes.

Through a local magazine article telling about our club's plans to build a small observatory for housing a 10-inch reflector that had been given us, a civic-minded woman donated $350 toward its construction, and a piece of land was made available high in the hills. A local architect, who considers our project worth while, drew plans for the observatory. Although we have our building permit, we cannot go ahead with the project until we raise more money, which we hope will be soon.

EDITH PHILLIPS
370 Anita St.
Laguna Beach, Calif.

FLINT, MICHIGAN

The Flint Astronomy Club in its second year has a membership of 50 juniors and seniors. The Mott Foundation of Adult Education sponsors the organization, which meets monthly at the Mott science building. A 9-inch telescope, placed in its custody by the Flint board of education, will soon be mounted on top of the building.

The club expects interest to increase when a Spitz planetarium is installed at the Flint College and Cultural Center. The instrument is being donated by Robert T. Longway.

More information may be obtained from Irene Majeski, 610 Grace St., Flint, Mich.

EAST CLEVELAND, OHIO

A series of open nights for the public is being held at the Warner and Swasey Observatory, Taylor Rd., East Cleveland, Ohio. The lectures begin at 8 p.m.

The topic for December 6th and 7th will be "Pluto and Its Place in the Solar System," and for January 10th and 11th, "Cosmic Rays."

For reservations, call the Warner and Swasey Observatory, GLenville 1-5625, between 1 and 5 p.m.

Planetarium Notes

(Most planetariums give group and special showings by appointment.)

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: Monday (Sept.-June), 3:45 p.m.; Thursday, 7:15, 7:45, 9:00 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BLOOMFIELD HILLS, MICH.: *McMath Planetarium.* Cranbrook Institute of Science, Bloomfield Hills, Mich.

SCHEDULE: Saturday and Sunday, 2:30 and 3:45 p.m. Spitz projector. In charge, James Carmel.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sunday, 2:00 to 4:30 p.m. (except summer). Admission free. Spitz projector. Director, Fred Hall.

CHAPEL HILL: *Morehead Planetarium.* Univ. of North Carolina, Chapel Hill, N. C.

SCHEDULE: Daily at 8:30 p.m.; also 11 a.m. and 3 p.m. Saturdays, 3 and 4 p.m. Sundays. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium,* Children's Museum, Public Library Building, Charleston, W. Va.

SCHEDULE: Saturday, 11 a.m. Admission free. Spitz projector. Director, Mrs. R. L. Sullivan.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 2-1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Tuesdays and Fridays, 8 p.m.; Sundays, 2 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

DALLAS: *Dallas Planetarium.* Dallas Health Museum, Fair Park, Dallas 10, Tex., HA 8-5755.

SCHEDULE: Saturday, 11 a.m.; Sunday, 2:30 and 4:30 p.m. Spitz projector. Director, Mrs. Claudia Robinson.

DENVER: *Denver Museum of Natural History Planetarium.* City Park, Denver, Colo., East 2-1808.

SCHEDULE: Saturday and Sunday, 1 to 4:30 p.m. Spitz projector.

FT. WORTH: *Charlie M. Noble Planetarium.* Ft. Worth Children's Museum, 1501 Montgomery St., Ft. Worth, Tex., PA-1461.

SCHEDULE: Tuesday through Saturday, 11 a.m., 1:30 and 2:30 p.m.; Sunday, 2:30 p.m. Spitz projector. Director, William Hassler.

INDIANAPOLIS: *Holcomb Planetarium.* Butler University, Indianapolis 7, Ind.

SCHEDULE: Saturday and Sunday, 4 and 8 p.m. Spitz projector. Director, Harry E. Crull.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 23, Mo., Humboldt 3-8000.

SCHEDULE: Saturday and Sunday (except first weekend of month), 3 p.m. Spitz projector. Director, Kenneth W. Prescott.

LANCASTER, PA.: *North Museum and Planetarium.* Franklin and Marshall College, Lancaster, Pa.

SCHEDULE: Tuesday and Thursday, 8 p.m.; Saturday and Sunday, 3 p.m. Admission free. Spitz projector. Curator, John W. Price.

LAQUEY, MO.: *Tarbell Planetarium.* Inca Cave Park, Laquey, Mo.

SCHEDULE: Alternate Sundays, 1 to 6 p.m., continuous. Spitz projector. Director, E. D. Tarbell.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 27787, Los Feliz Station, Los Angeles 27, Calif., Normandy 4-1191.

SCHEDULE: Daily (except Monday and Tuesday), 8:30 p.m.; also at 3 p.m. on Saturday and at 3 and 4:15 p.m. on Sunday. Zeiss projector. Director, Dinsmore Alter.

MINNEAPOLIS: *Science Museum.* Minneapolis Public Library, 1001 Hennepin Ave., Minneapolis 3, Minn.

SCHEDULE: Saturday, 10 a.m. and 2 p.m. Admission free. Spitz projector. Curator of education, Maxine B. Haarstick.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., 42-1858.

SCHEDULE: Sunday, 2:45, 3:30, 4:15. Spitz projector. Assistant curator of education, Donald Davis.

NEWARK: *Newark Museum Planetarium,* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.

SCHEDULE: Saturday, Sunday, and holidays, 2:30 and 3:30 p.m. Admission free. Spitz projector. In charge, Ray Stein.

NEW YORK CITY: *American Museum—Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 1, 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 1, 2, 3, 4, 5, and 8:30 p.m. Zeiss projector. Chairman, J. M. Chamberlain.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 1-4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays, 2:15, 4:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Oregon Museum of Science and Industry Planetarium.* 908 N.E. Hassalo St., Portland 12, Ore., East 3807.

SCHEDULE: Saturday and Sunday, 3:00 p.m. Spitz projector.

PROVIDENCE: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.

SCHEDULE: Saturdays, Sundays, and holidays, 3 and 4 p.m. (Oct.-June). Admission free. Spitz projector. Director, Maribelle Cormack.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.

SCHEDULE: Daily (except Monday and Tuesday) at 3:30 and 8:30 p.m.; also at 2 p.m. on Saturdays, Sundays, and holidays. Academy projector. Curator, George W. Bunton.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8:30 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, F. Korkosz.

SKY-GAZERS EXCHANGE

Classified advertising costs 20 cents a word, including address; minimum charge, $3.00 per ad. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., *Sky and Telescope,* Harvard Observatory, Cambridge 38, Massachusetts.

WANTED: A sidereal clock. Neil E. Hopkins, 409 Hillcrest Rd., York, Pa.

FOR SALE: 4" equatorial reflecting telescope, Cave mirror, nice instrument, $150.00. For particulars write E. B. Kille, 8215 2nd Ave., Inglewood 4, Calif.

FOR SALE: Link collimators. Each contains 5", f/5 achromat which makes spectacular rich-field objective. Regularly $95.00; last two offered for only $69.50 each, postpaid. Dick Nelson, 1033 Dolores Drive, Altadena, Calif.

FOR SALE: Secretan telescope, practically new. 4" lens, ground by French expert. 6 eyepieces; celestial and terrestrial. Tripod mounted, with slow motions, finder, and counterbalances. Solar shade. Cost $850.00, will accept $425.00. V. A. Corradini, 1148 La Rosa Rd., Arcadia, Calif.

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WILL BUY 16" pyrex mirror blanks. Kindly write your specifications and price. Robert Konopa, 315 Harvard St., Green Bay, Wisc.

FOR SALE: Binocular telescope; Busch; with 80-mm. objectives and three paired eyepieces, turret style; magnifications, 12x, 20x and 40x; tripod. Good condition. Price, $400.00. Dr. I. H. Katz, 713 E. Genesee St., Syracuse 2, N. Y.

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SMITHSONIAN ASTROPHYSICAL OBSERVATORY

BULLETIN FOR

Visual Observers of Satellites

NUMBER 4 | 60 GARDEN STREET, CAMBRIDGE 38, MASS. | DECEMBER, 1956

A Hundred MOONWATCH Stations Ready for December 8th Alert

Throughout the United States, volunteer observers who have undertaken to establish and operate MOONWATCH satellite stations have been devoting vast amounts of time and effort to the important scientific task that lies ahead of them. Although the program started only in the spring of this year, the response of dependable volunteers has far surpassed expectations.

Problems of organization, observing sites, instrumental equipment, and preliminary instruction of observers were trying in many cases. Smithsonian Astrophysical Observatory astronomers have been gratified by the earnestness and imagination of the group leaders and their team members in planning to procure the data that will be used in satellite orbit computation.

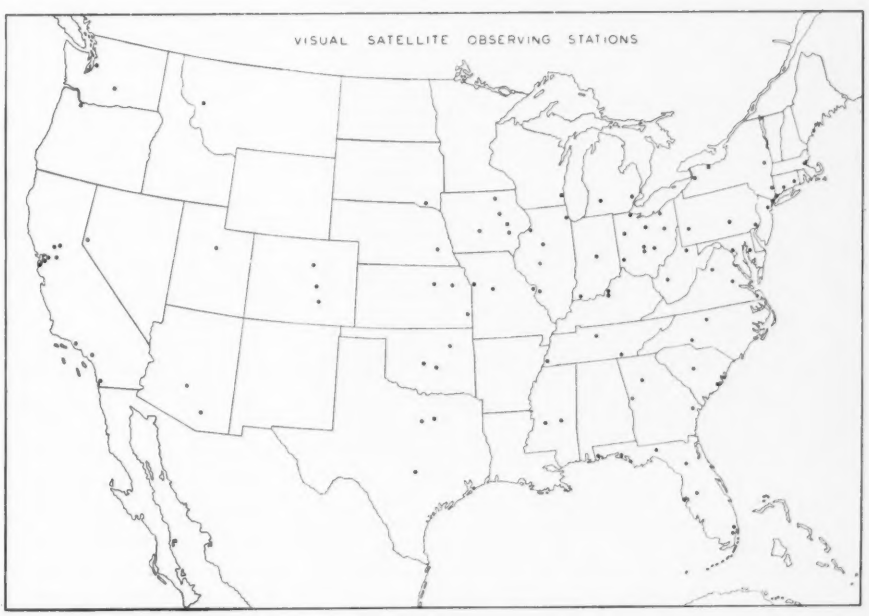
The map below indicates the locations of expected satellite observing stations as of the end of October, 1956. Each station will scan a sky area at least eight degrees wide and 90 to 120 degrees long; in many cases station fields will overlap and two or more teams ought to report the satellite passage nearly simultaneously.

But the map also shows a number of regions virtually without watchers, yet in these same areas atmospheric conditions may be much better than average. Therefore, we need more observing teams in such sparsely populated regions, to guarantee reporting of the satellite on every possible meridian passage.

The mailing list for those copies of the *Bulletin* that are distributed separately from *Sky and Telescope* is being revised. For as the requirements of project MOONWATCH become more stringent, our future numbers will deal with observing techniques, problems of the reporting system, and the like. They will contain specific information for observers and teams officially co-operating with the project, but other persons with justifiable reasons will be kept on the mailing list at their request.

Now that observing teams are definitely registering, in accordance with the instructions in *Bulletin* No. 3, the Smithsonian Astrophysical Observatory will issue directives to the observers through their team leaders, who will be responsible for transmitting such information to all of their associates.

ARMAND N. SPITZ
Coordinator of Visual Satellite Observations

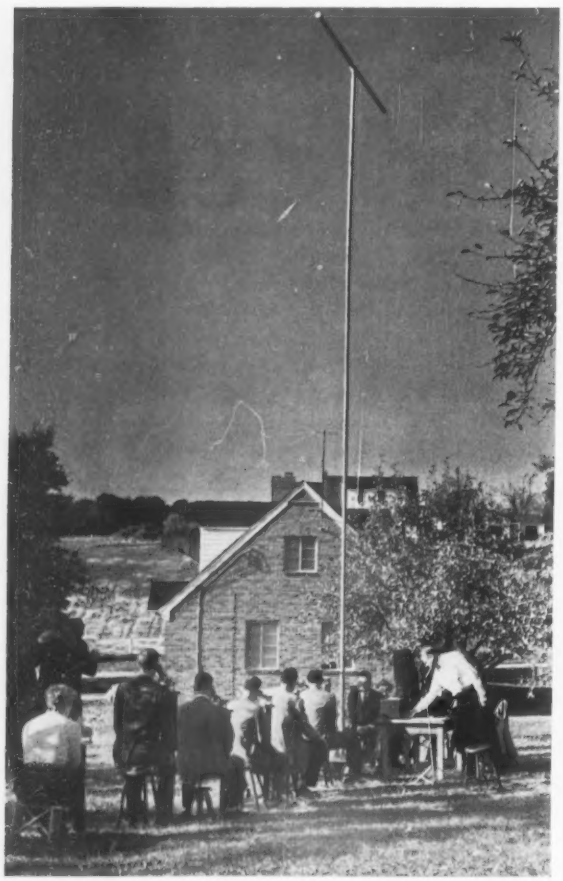


This map of the United States has nearly 100 points plotted to show the location of stations that are expected to take part in the first MOONWATCH alert on December 8th. Each of these stations will cover a strip of the meridian eight degrees wide and extending in a north-south direction about 100 degrees or more. At an altitude of 200 miles, the minimum distance proposed for the first satellite, these angles correspond to approximately a width of 28 miles and a length of 460 miles. At 800 miles, the probable apogee distance, the width of the area covered will be over 110 miles and the length about 1,700 miles.

IX. MOONWATCH Alert, December 8, 1956

Shortly after sunset on Saturday, December 8th, the first nationwide MOONWATCH alert will take place. At that time, all registered teams across the United States are expected to hold *serious* satellite observing practice sessions. The alert is to be carried out at every station, *whether the sky is cloudy or clear.* The event will not only be a dress rehearsal in which each team gains practice and experience in observation and communication; there is also a real possibility that a nearby natural earth satellite may be discovered.

All observers should assemble well in advance of sunset for this first practice session, as trial runs are apt to take more time than anticipated. Start observations 15 minutes after sunset (practically the earliest sunset of the year) and continue 1 hour 40 minutes to well after the end of astronomical twilight. On future occasions, it may be necessary to observe even beyond this period.



At his home in Silver Spring, Maryland, the chairman of the national advisory committee, G. R. Wright (leaning over control box) set up this satellite observing station. The observers are lined up along the meridian. All photographs by Mrs. Wright.

Clear or cloudy, whether the station observes a simulated satellite or not, the acting station leader must report to Cambridge, Massachusetts, that evening by telephone, or by radio if prior arrangements have been made, in order to remain part of the active MOONWATCH network.

Incompletely equipped or manned stations should also take part in this first alert, going through the entire observing routine with simulated instruments, if necessary. Such an operation will give the available observers valuable practice and will emphasize the incompleteness of the station's preparations.

Detailed instructions for the registered leader of each station will be mailed prior to the alert. These will include how to call, code number, telephone number, and the like. Several telephone lines will be in service at the Smithsonian Visual Tracking Center in Cambridge. As the twilight zone advances across the country, reports from all stations will be received and analyzed. Although few stations will be favored with simulated satellites, the report from every participating station will be essential as a check that no breakdown in communication will occur when the actual satellite is launched.

On December 8th, calls will be accepted only from station leaders or their duly appointed alternates, using their proper station code numbers. The communication center will not receive calls from unofficial observers or individual team members.

At this time plans are well advanced for having simulated satellites (weather balloons or high-flying airplanes with faint lights) pass over some MOONWATCH stations. These plans, however, will not be made generally known, in order that the effectiveness of the MOONWATCH alert can better be judged.

All stations that have not registered with Smithsonian Astrophysical Observatory headquarters are urged to do so immediately, in accordance with the instructions in *Bulletin* No. 3. It is extremely important to have the exact *geographical latitude and longitude* and the station's elevation above sea level. The co-ordinates of the nearest city or town will not suffice. Sufficiently accurate positions can be scaled off on a geodetic map of the area. Such maps are available from local government offices, surveyors' files, or by writing to the U. S. Coast and Geodetic Survey, Washington 25, D. C. The accurate co-ordinates are needed so they can be introduced in advance into the electronic computing machines that will be used to calculate the satellite orbit immediately after the first observations are received.

The communications necessary for this first alert will allow the Smithsonian staff to become better acquainted with station leaders and to receive constructive suggestions from participants. The purpose of the alert is to find mistakes and to correct them before the satellite is placed in its orbit.

In another view of the Silver Spring MOONWATCH station, observers prepare for a practice session. There are six observers on each side of the meridian mast (three on the left not shown). The manner of mounting the observing telescopes can be seen.

X. Making and Reporting Satellite Observations

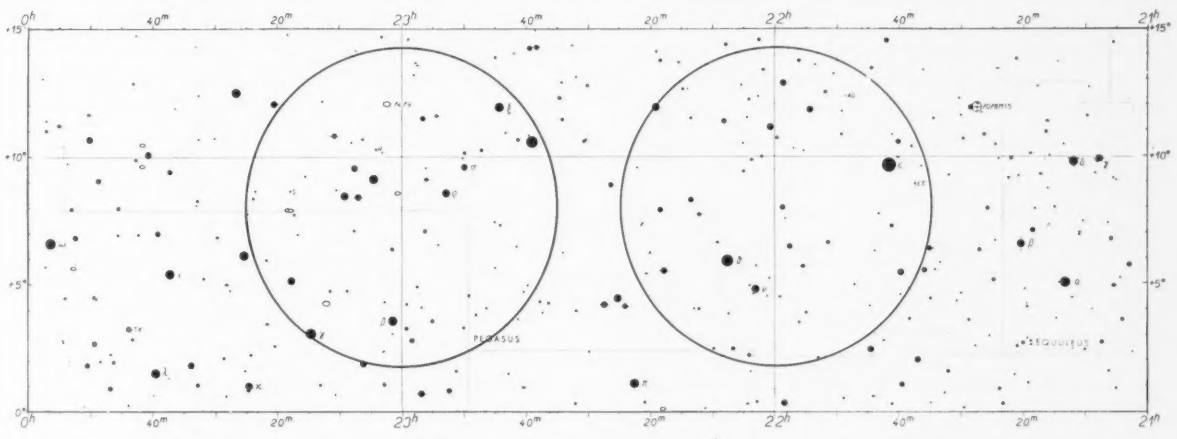
A. Star Charts. Each observer will see in his field of view the mast and crossbar that define his meridian and orient the field. If it is dark enough to detect the satellite, the observer will also have a field of stars which will move very slowly across the field of view.

The star background forms an array of precise reference points against which satellite observations can be made. Although timing of the passage of the satellite is of paramount importance, the position of its path with reference to the mast and the star field must be obtained as accurately as possible. Time and position are both necessary.

Therefore, each observer will need a chart of stars covering a range of declination equal to or greater than the width of his field of view, and on a scale large enough to determine position within ¼ degree. The chart should be centered on the declination of the center of the field, which is determined by the latitude of the site and the observer's assigned position on the meridian.

Copies of the Skalnate Pleso *Atlas of the Heavens* will be furnished to each registered station, and these can be cut into sections appropriate to the needs of the team members. The magnitude limit is 7.75, quite suitable for twilight observing with instruments of low power. Since they will receive hard use, each chart section should be mounted on heavy cardboard, and a protective coating can be applied if it does not interfere with the need to write on the chart surface.

Index marks for specific times during morning and



A portion of the Skalnate Pleso Atlas of the Heavens *(reproduced half size), as would be used by an observer during the alert of December 8th. The right-hand circle shows his 12-degree field of view, centered at declination +8°, when the right ascension of the meridian is 22h, not long after sunset. The circle at the left shows the position of the field an hour later. (In a standard MOONWATCH instrument, this view will be turned right for left.)*

evening twilight may be placed on the charts and a movable time scale provided. The transparent grids supplied with each atlas cover one hour of right ascension; these can aid accurate determination of the meridian after an observation has been made, but observers should not depend on such devices to locate stars in their field of view.

Thus, each observer must become so familiar with his zone of the sky that he can immediately identify any field in it and locate that field on the charts in a matter of seconds. Obviously, the charts must be kept close at hand during the entire observing period.

B. Making the Observations. The following procedure for each satellite observer will provide all the desired information:

1. During Transit of the Satellite

a. Give appropriate signals so that time will be recorded at the following critical instants:

1. When the satellite is first observed.
2. When the satellite disappears behind the mast.
3. When the satellite leaves the field of view.

b. Mentally record as accurately as possible the complete path of the satellite with respect to the stars as it crosses the field of view.

c. Note the position of the western edge of the mast with respect to the background stars.

d. Estimate the satellite's brightness relative to one or two stars in the field.

2. Immediately After the Satellite Has Left the Field

a. Sketch the path of the satellite on the star chart; also the position of the western edge of the mast.

b. Mark the points on the satellite's path where the times were recorded.

c. Determine the magnitude of the satellite relative to the stellar magnitudes obtained from the star chart.

3. In Consultation, the Group Leader, the Observer, and the Timekeeper Will

a. Determine the time of disappearance of the satellite behind the mast, also its right ascension and declination at that time. (This is the most essential information that must be reported to headquarters.)

b. Measure with a protractor the position angle of the satellite's track on the chart.

c. Calculate the angular velocity of the satellite, making use of the times and positions recorded on the chart.

C. Reporting the Observations. The station leader will transmit, in prearranged form, the following data to Cambridge:

1. Station leader's name, and the name and code number of the station.
2. Time of disappearance of the satellite behind the western edge of the mast.
3. Right ascension and declination of the position of disappearance behind the mast.
4. Position angle of the satellite path.
5. Angular velocity of the satellite.
6. Magnitude of the satellite.
7. Number of observers participating.
8. Times of beginning and ending of the observing period.
9. Weather and atmospheric (seeing) conditions.

For the practice alerts, we are asking that all sightings of moving objects (except birds) be reported. When a real satellite is in its orbit, only possible satellite observations should be reported.

The report should be prepared in written form at the time it is transmitted by telephone. Together with the marked star charts, a copy of the report should be mailed without delay to

Smithsonian Visual Tracking Center
60 Garden St., Cambridge 38, Mass.

After the alert on December 8th, and after subsequent alerts, the station leader should send in a supplementary report with explanations, suggestions, and comments on the functioning of the station during an alert period—information that cannot be included in the short telephone report. The station leader should retain copies of these official reports in his files.

SMITHSONIAN ASTROPHYSICAL OBSERVATORY
I.G.Y. Satellite Optical Tracking Program

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BOOKS AND THE SKY

STONEHENGE

R. J. C. Atkinson. Hamish Hamilton Ltd., 90 Great Russell St., London W.C. 1, 1956. 210 pages. 16s.

WRITTEN by one of the three archeologists in charge of the current excavations at Stonehenge, this book summarizes past and present views and information concerning this British monument. The volume is well written, and included among the illustrations is a map that folds out to show the locations of all the monoliths and other features of the ancient site.

For a person interested in prehistory and monuments of this type, the book should prove extremely interesting. Besides chapters dealing with the composition of its stones, the possible uses of the monument by ancient peoples, and other related problems, there is a chapter devoted to a summary of the previous work and speculation.

The reader interested primarily in astronomy, however, will find little of value except the author's attempt on archeological grounds to de-emphasize the importance of dating the monument by astronomical techniques.

There is general agreement that the structures of Stonehenge were aligned, in the words of Dr. Atkinson, "roughly and approximately on the midsummer sunrise," or the point where the sun rises on the first day of summer. We can accept this as fact, but no one knows why or when this was done, particularly since various groups of circles and formations of stones at Stonehenge are themselves of different dates.

In 1901, Sir Norman Lockyer (not Astronomer Royal as the author says) undertook to answer the question "when" in the following manner. He assumed that the axis of the "avenue," running from the center of Stonehenge in the direction of the "heelstone," was aligned accurately by the builders to point at the position of the sunrise that took place at the summer solstice. The axis he chose was found to have an azimuth or bearing of 49° 34′ 18″ east of true north. The obliquity of the ecliptic must, therefore, have been 23° 54′ 30″ in order for the particular sunrise to have taken place at the end of this axis. Lockyer calculated from this information that the date of construction must have been 1680 ± 200 B.C. His computation was based on tables for the obliquity of the ecliptic published in 1873; more recent computations give 1840 ± 200 B.C.

Atkinson points out several fallacies in this reasoning. Without going into the complete details, we can summarize and comment briefly on his main arguments:

First, the accuracy with which the date can be fixed by Lockyer's method depends, in the last analysis, on the accuracy with which the ancient builders were able to align the axis to the sunrise point. This certainly is a consideration worth keeping in mind.

Second, Lockyer made several fallacious assumptions concerning the alignment of the axis on the ground, which Atkinson says cannot be determined accurately even

These sarsen trilithons have been standing at Stonehenge nearly 4,000 years. The view here is across the central area of the monument toward the northeast, along the "avenue" to the heelstone that may be seen in the distance through the central opening. Photograph by C. A. Federer, Jr.

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today. For unknown reasons, Lockyer apparently connected the axis of Stonehenge with the positions of two mounds some distance from it, but these are Iron Age relics and not related to Stonehenge.

Third, no one knows precisely what the ancients considered the moment of sunrise. Was it when the first direct light appeared? Was it when the horizon divided the sun exactly in half? Or was it the instant that the sun came completely above the horizon? Lockyer assumed the first case.

When we consider that there is a possible difference of 4,000 years between the first case and the last in the resulting dating of the monument, I think everyone would have to agree that Lockyer made the proper choice, as the astronomical value for the date agrees so closely with the archeological. Despite this agreement, however, and in view of the other arguments, it may very possibly be a matter of chance that approximately the same answer is given by totally different disciplines. This is the view Atkinson takes.

GEORGE S. MUMFORD, III
Tufts University

A CLASSIFICATIONAL CATALOG OF THE METEORITIC FALLS OF THE WORLD

Frederick C. Leonard. University of California Press, Los Angeles, 1956. 79 pages. $1.75, paper bound.

THIS very compact contribution from Frederick C. Leonard, assisted by Robert de Violini, lists 1,563 meteorites, all that were well authenticated as of November 1, 1955. The book forms the first part of the second volume in the University of California *Publications in Astronomy.*

The data listed for each fall are the name (generally of the state, province, or country), the co-ordinate number representing the latitude and longitude of the fall, total weight and number of masses found, and the date and time of the fall (or of the finding of the meteorites or of their recognition).

The system of classification, devised mainly by the senior author, gives in minimum space a wealth of information on the internal structure and mineral composition of the meteorite. To a novice unfamiliar with the terminology of meteoritics, the degree of abbreviation used might at first appear overwhelming, but the experienced meteoriticist soon prefers Ap^6p^7o, for example, to its long-hand equivalent, olivine-hedenbergite-diopside achondrite. The convenient tables for translating symbols occupy only a few pages of the introduction, whereas the written-out classifications would be too long for one-column tabulation.

Therefore, the tabulated material in this 79-page booklet gives information that, in a different form of presentation,

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might easily have required a large volume. The main body of the catalogue is arranged according to the classification of the meteorite: aerolites (achondrites and chrondrites), siderolites (sideraerolites and lithosiderites), and siderites (hexahedrites, octahedrites, and ataxites), with some 30 subclasses according to the mineral composition. A later section, in the alphabetical order of the name of the fall, gives cross references to the classification and page in the primary table.

On page 60 is a table of the authenticated meteorite craters of the world. There are 14 entries, half of them representing groups of related craters.

Special attention is called to the number and percentage of meteorite falls that require more precise classification. Of the 1,563 falls, 683, or nearly 44 per cent, require further analysis of their mineral composition. This extensive compilation should therefore greatly assist anyone planning research on meteorites, enabling him to fill in gaps and avoid duplication in mineralogical analysis.

DORRIT HOFFLEIT
Yale University Observatory

NEW BOOKS RECEIVED

ASTRONOMISCHER JAHRESBERICHT, Vol. 54, 1956, *Astronomisches Rechen-Institut*, Grabengasse 14, Heidelberg, West Germany. 517 pages. DM 40, paper bound.

This current volume of a standard reference work is a comprehensive listing of the astronomical literature published during 1954. The titles are arranged by subject, and all important article references are accompanied by a short abstract in German.

GENERAL RELATIVITY AND COSMOLOGY, *G. C. McVittie*, 1956, *Wiley*. 198 pages. $9.00.

This volume, the fourth in the International Astrophysics Series, originated from lectures given by the author during the past 10 years in the universities of London, Harvard, and Illinois. Dr. McVittie examines general relativity as a method in mathematical physics and astronomy, and as a means for interpreting observational data.

SPECTROSCOPY AT RADIO AND MICROWAVE FREQUENCIES, *D. J. E. Ingram*, 1956, *Philosophical Library*. 332 pages. $15.00.

Although this book contains a general approach to radio spectroscopy for non-specialists, considerable space is devoted to the design of experimental apparatus and equipment for radio spectroscopes.

CLOUDS, RINGS AND CROCODILES, *H. Percy Wilkins*, 1955, *Little, Brown*. 148 pages. $3.00.

The author gives a fanciful account of a rocket trip through space to the moon and several planets. The "crocodiles" in the title refer to supposed creatures encountered on the planet Venus. Dramatic episodes, such as escaping a roasting by the sun, interrupt the smooth sailing.

EARTH SATELLITES, *Patrick Moore*, 1956, *Norton*. 157 pages. $2.95.

Written for the general reader, the book deals with the artificial satellite program as it affects science, politics, and the future of man.

HOW TO MAKE AND USE A TELESCOPE, *H. Percy Wilkins* and *Patrick Moore*, 1956, *Norton*. 196 pages. $2.95.

This book takes the amateur step by step through the process of telescope construction, briefly describing the various types and the problems of building them in the home workshop. The authors devote a considerable portion to using the telescope.

ATOMIC ENERGY, *A. Radcliffe* and *E. C. Roberson*, 1956, *Philosophical Library*. 142 pages. $4.75.

This book, one from "The True Book About . . ." series for juniors, tells how the existence of atoms was proved and shows how they can be used for the benefit of man.

L'ORIGINE DES PLANÈTES, *Alexandre Dauvillier*, 1956, *Presses Universitaires de France*, 108 Boulevard Saint-Germain, Paris, France. 224 pages. 800 fr., paper bound.

In French, this small volume gives a detailed treatment of the various theories of the formation of the solar system. Special consideration is given to the theory of Laplace and the collision and accretion hypotheses.

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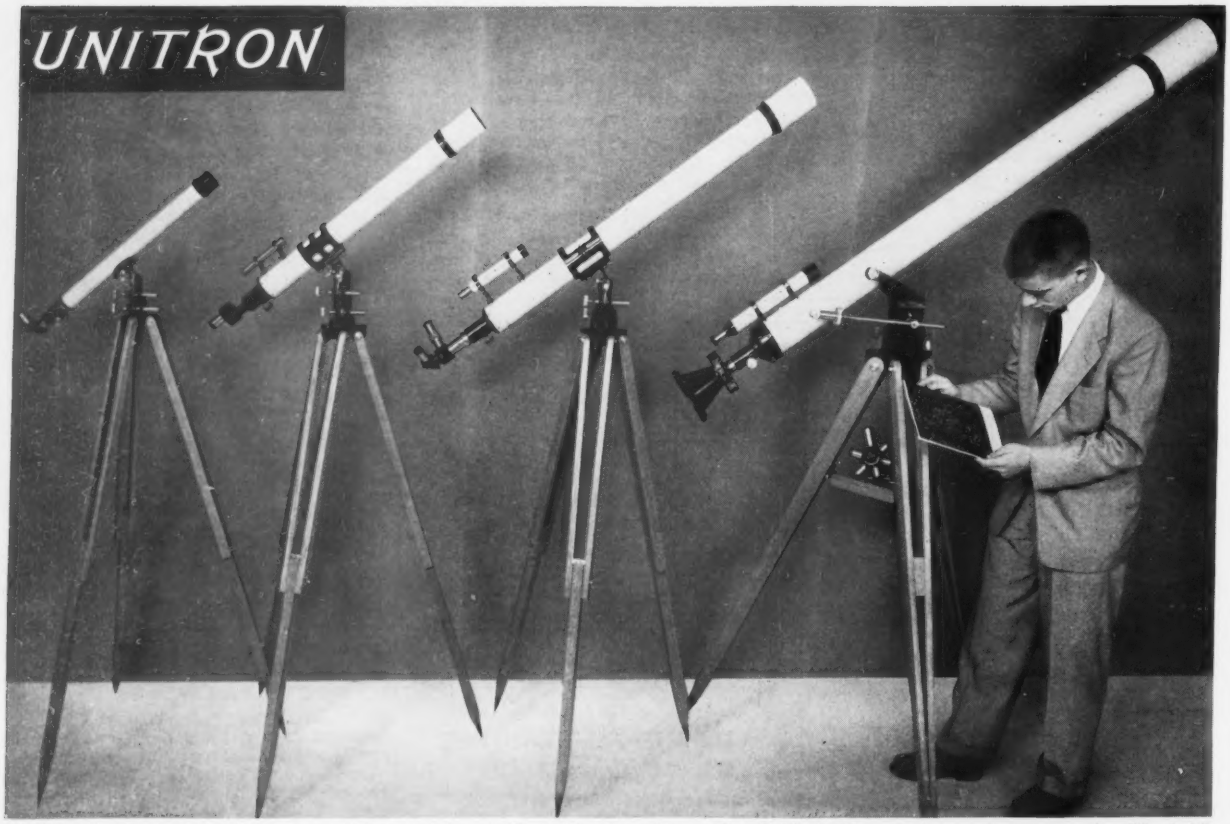

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with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x

4" ALTAZIMUTH ($116 Down) with **$465**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x

4" EQUATORIAL ($196 Down) with **$785**
eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" PHOTO-EQUATORIAL ($222 Down) **$890**
with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x

4" PHOTO-EQUATORIAL with clock **$1175**
drive and astro-camera ($294 Down), with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

4" PHOTO-EQUATORIAL with clock **$1280**
drive, fixed pier, astro-camera ($320 Down), with eyepieces for 375x, 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

Higher- and lower-power eyepieces available for all models.

Prices include basic accessories, tripod and mounting, fitted wooden cabinets, and operating instructions.

Additional accessories available to add further to your observing pleasure.

Here is a gift to bring pleasure to the whole family. Young and old alike will enjoy the intellectual stimulation of exploring the vast reaches of space with a UNITRON. On vacation, your UNITRON is an ideal companion and provides startling close-up views of distant terrestrial objects. Invest in a UNITRON for year-round pleasure for years to come.

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVES.
- REFRACTOR type of design duplicates the performance of larger telescopes of other types. No mirrored surfaces to become oxidized. Superior definition to the very edge of the field.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to nine eyepieces included with each instrument as standard equipment.
- FINEST MATERIALS throughout. DURALUMINUM TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No war-surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for *both* declination and right ascension as well as rapid-motion controls. Sturdy TRIPOD.
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- RACK-AND-PINION FOCUSING.
- Choice of UNIHEX Rotary Eyepiece Selector or STAR DIAGONAL and ERECTING PRISM for TERRESTRIAL OBSERVATION. The same complete range of terrestrial magnifications as for celestial observation.
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Send check or money order in full or use our Easy Payment Plan, as described below. Shipments made express collect. Send 20% deposit for C.O.D. shipment. All instruments are stock items and Christmas orders will be shipped the same day as received. For special rush orders and information, telephone HAncock 6-9878 (Boston exchange) and ask for "Christmas Order Department." UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.

Use Our EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 25%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled.

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Do not hesitate to use this plan merely because you have never before purchased anything on time payments. The procedure is practically painless and is an ideal means of enjoying the use of your UNITRON while paying for it.

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UNITRON ACCESSORIES make ideal gifts for those astronomers on your Christmas list. Components available include objective lenses, eyepieces, rack-and-pinion focusing mechanisms, sun projecting screens, guide telescopes, the UNI-CLAMP camera brackets, and many others in addition to those listed on this page. All are described, illustrated, and priced in the new UNITRON Catalog. Since each component is used as standard equipment in UNITRON Refractors themselves, you are assured of the finest quality.

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DUETRON Double Eyepiece: With DUETRON, two observers may use the telescope simultaneously and with equal comfort. The eyepieces used need not necessarily be of the same magnification. DUETRON is a real boon for father-and-son observing teams. With DUETRON, more observers may be accommodated at star parties, and the advanced members may provide valuable instruction to the beginners. The tube of DUETRON Model A is interchangeable with the customary UNITRON drawtube and may be used with all models with the exception of the 1.6" Refractor. DUETRON Model B fits 1¼" eyepiece holders. Complete with special clamping device and cabinet. A or B:

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1. VIEW FINDER (As shown on UNITRON 2.4" Equatorial): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.

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2. VIEW FINDER (As shown on UNITRON 3" Altazimuth): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3.

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3. VIEW FINDER (As shown on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duraluminum tube finished in white enamel. Dew-cap. Furnished with mounting brackets with centering screws for collimation. This finder also makes an excellent hand telescope for spectacular wide-field views of the sky.

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We offer the lowest priced, hand-corrected, precision, American-made astronomical objective, *mounted in a black anodized aluminum cell.* Our reputation has been established over the years as the most reliable source of high quality astronomical lenses.

"Those in the know" BUY FROM US BECAUSE:

Each lens is thoroughly tested by us and is guaranteed to resolve two seconds of arc or better. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cell is machined to close tolerances so that it will fit directly over our standard aluminum tubing, eliminating any mounting problems.

3¼" diam., 48" f.l. (uncoated).. **$28.00**
Same as above with coating..... **$32.00**
4⅛" diam., 62" f.l. (uncoated).. **$60.00**
Same as above with coating..... **$69.00**

We can supply ALUMINUM TUBING for the above lenses.

"BIG" ACHROMATIC TELESCOPE OBJECTIVES

We have the largest selection of diameters and focal lengths in the United States available for immediate delivery. These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power. They can readily be used with eyepieces of only ¼" focal length, thereby producing high powers. Guaranteed well suited for astronomical telescopes, spotting scopes, and other instruments. Gov't. cost up to $100.

Diameter	Focal Length	Each	Diameter	Focal Length	Each
54 mm (2⅛")	254 mm (10")	$12.50	83 mm (3¼")	660 mm (26")	$28.00
54 mm (2⅛")	300 mm (11.8")	12.50	83 mm (3¼")	711 mm (28")	28.00
54 mm (2⅛")	330 mm (13")	12.50	83 mm (3¼")	762 mm (30")	28.00
54 mm (2⅛")	390 mm (15.4")	9.75	83 mm (3¼")	876 mm (34½")	28.00
54 mm (2⅛")	508 mm (20")	12.50	83 mm (3¼")	1016 mm (40")	30.00
54 mm (2⅛")	600 mm (23½")	12.50	102 mm (4")	876 mm (34½")	60.00
54 mm (2⅛")	762 mm (30")	12.50	108 mm (4¼")	914 mm (36")	60.00
54 mm (2⅛")	1016 mm (40")	12.50	110 mm (4⅜")*	1069 mm (42⅛")	60.00
54 mm (2⅛")	1270 mm (50")	12.50	110 mm (4⅜")	1069 mm (42⅛")	67.00
78 mm (3⅛")	381 mm (15")	21.00	128 mm (5⅛")*	628 mm (24¾")	75.00
80 mm (3⅛")	495 mm (19½")	28.00	128 mm (5⅛")	628 mm (24¾")	85.00
81 mm (3⅜")	622 mm (24½")	22.50	*Not coated		

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American Type Zeiss Type

Beautiful imported binoculars, precision made, at a low, low price. Above we have pictured the two most popular types. The American Type offers a superior one-piece frame and a clean design, pleasing to the eye. Complete with carrying case and straps. **Price plus 10% Federal tax.**

SIZE	TYPE	C. FOCUS	IND. FOCUS
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6 x 30	ZEISS	$18.75	16.75
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7 x 35	AMERICAN	23.50	—
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7 x 50	ZEISS	24.95	22.50
7 x 50	AMERICAN	32.50	—
8 x 30	ZEISS	21.00	18.25
10 x 50	ZEISS	30.75	28.50
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MONOCULARS

Brand new, coated optics, complete with pigskin case and neck straps.

	Price		Price
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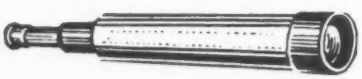

40 power Special Price **$57.50**

Never before has anything like this been offered at so low a price. Here is another example of American ingenuity. Big 3" diameter achromatic coated objective which will give needle-sharp crystal-clear images. Focusing is a delight with the micrometer spiral focusing drawtube. Light-weight aluminum construction throughout, black crackle finish, length open 22 inches, closed 17 inches. This telescope gives an upright image—it is WONDERFUL for astronomy, SUPERB for long distances, EXCELLENT as a spotting scope.

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WIDE ANGLE ERFLE (68° Field) **EYEPIECE.** Brand new coated 1¼" E.F.L. Focusing mount. 3 perfect achromats, 1⅜" aperture. **$12.50**

WIDE ANGLE ERFLE 1½" E.F.L. Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field.. **$18.50**

1¼" **Diam. Adapter** for above eyepieces. **$3.95**

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500 sheets size 7½" x 11"..... **$1.00**

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The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black anodized standard aluminum 1¼" O.D. mounts.

F.L.	TYPE	PRICE
12.5 mm (½")	Symmetrical	$ 6.00
16 mm (⅝")	Erfle (wide angle)	12.50
16 mm (⅝")	Triplet	12.50
18 mm (¾")	Symmetrical	6.00
22 mm (27/32")	Kellner	6.00
32 mm (1¼")	Orthoscopic	12.50
35 mm (1⅜")	Symmetrical	8.00
55 mm (2⅛")	Kellner	6.00

COATED 75 cents extra.

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These mirrors are of the highest quality, polished to ¼-wave accuracy. They are aluminized, and have a silicon monoxide protective coating. You will be pleased with their performance.

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Plate Glass	3⅜"	42"	$ 9.75
Pyrex	4¼"	45"	$13.50
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This mounted eyepiece has two magnesium-fluoride coated lenses 29 mm in diameter. It is designed to give good eye relief. It has an effective focal length of 1¼" (8x).

The eyepiece cell fits a 1¼" tube..... **$4.50**

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O.D.	I.D.	Price Per Ft.
2¼"	2⅛"	$1.20
3⅜"	3¼"	1.75
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5"	4⅞"	2.75

All tubing is shipped POSTPAID.

Focusing Eyepiece Mounts Rack & Pinion Type

The aluminum body casting is finished in black crackle paint and is machined to fit all our aluminum tubing. Has a chrome-plated brass focusing tube, which accommodates standard 1¼" eyepieces.

For 2⅛" I.D. Tubing	Postpaid	$12.95
For 3¼" I.D. Tubing	"	12.95
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Reflector type for all size tubing.

Complete with diagonal holder..... $ 9.95

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Cell for Lenses	Cell Fits Tubing	Price
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78 mm "	3¼" "	6.50
81 mm "	3¼" "	6.50
83 mm "	3¼" "	6.50
110 mm "	4⅜" "	10.50

3X TELESCOPE

Makes a nice low-priced finder. Brand new; has 1" Achromatic Objective. Amici Prism Erecting System, 1⅜" Achromatic Eye and Field Lens. Small, compact, wt. 2 lbs. Gov't. Cost $200. **$9.75**

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Size	Thickness	Postpaid
14" x 16"	¼"	$10.00
8" x 10"	¼"	4.25
4" x 5"	¼"	1.85
4" x 4"	¼"	1.50
1¼" x 1½"	1/16"	.25

RIGHT-ANGLE PRISMS

8 mm face.....ea.	$ .75	28 mm face.....ea.	$1.75
12 mm face.....ea.	.75	38 mm face.....ea.	2.00
23 mm face.....ea.	1.25	47 mm face.....ea.	3.00

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The Custer 12½-inch Springfield Reflector — II

SPRINGFIELD reflectors have the great advantage that objects in any part of the sky can be observed while the eyepiece remains in a fixed position. The principle that allows this convenient result is illustrated in Fig. 5, where it is seen that light rays are reflected three times before entering the eyepiece. The observer sits with his back to the north star.

The construction of this useful type of telescope is more complicated than that of a conventionally mounted instrument, and the amateur who plans to make one can profit from a detailed description of a successful prototype, such as the 12½-inch Springfield built by Dr. Clarence P. Custer, of Stockton, California. Last month we described the tube, mirror, and diagonal system of his instrument. In this and our next installment we shall take a close look at the heart of the Springfield—the parts that make up the equatorial head. Here careful design and rugged construction are essential; though most amateurs deviate from the original Porter plan to some extent, as Dr. Custer has done, the basic principles remain the same.

Fig. 6 shows how the saddle for the tube is constructed, and its position on the mounting, as well as the hollow declination axle, its central hole being 1¾" in diameter. The horizontal rod with knobs at the ends is for fine setting in declination. The control switches in the base casting (since this picture was taken more have been added) are within easy reach of the observer.

The other side of the mounting is seen in Fig. 7, with the saddle turned as if the telescope were pointed to a star high in the northwestern sky. The welded tube saddle is bolted onto the combination brass setting circle and worm gear for declination immediately beneath it. In the center can be seen the worm and its motor drive; above the worm, fixed to the upper or angle casting, is a sharp pointer for reading the declination setting. The declination axis runs diagonally downward to the right in the picture, to the right-angle prism located over the polar axle, the hex-headed stud of which is barely visible underneath the

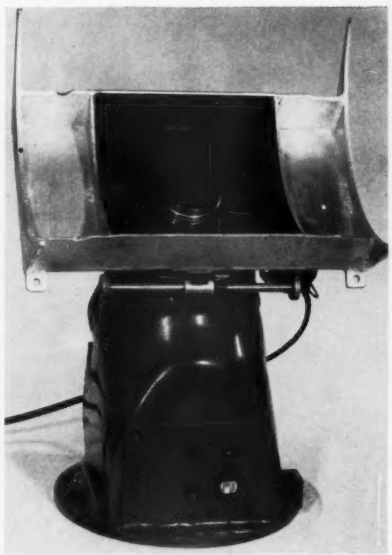


Fig. 6. The base casting and saddle seen from the south. The photographs with this article are by Tom McCoy.

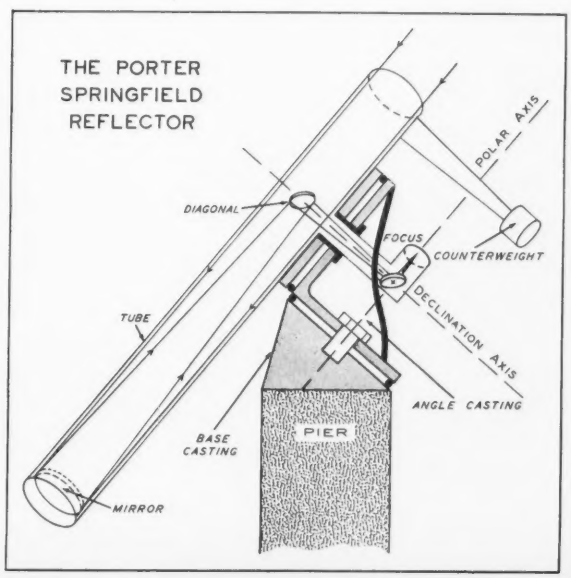
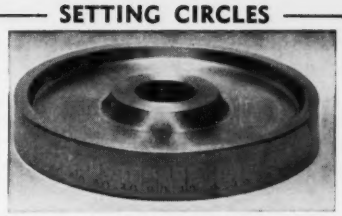


Fig. 5. In the type of telescope built by Dr. Custer, the primary mirror has a paraboloidal figure, and it reflects light to a diagonal flat as in a Newtonian. This flat is located at the intersection of the optical axis and the declination axis, down which the light is sent to a second flat or a prism, at the intersection of the declination axis and the polar axis. The eyepiece is in a fixed position regardless of where the telescope is pointed.

SETTING CIRCLES



Made of choice aluminum or brass, machined and polished all over. Hour circles machine-scribed with hour, half-hour, and five-minute marks. Declination circles scribed in degrees 0-90-0-90. Numbers stamped with ⅛" dies. Holes reamed standard sizes. State sizes.

	Aluminum	*Brass*
5" circles, set of two	$12.00	$15.60
6" circles, set of two	13.00	16.90
8" circles, set of two	20.00	26.00

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You will get the best possible performance from your telescope with one of our clear **fused quartz** diagonals. Accuracy guaranteed 1/20 wave.

Ellipse 1.25" x 1.77" . . $11.00
Ellipse 1.5" x 2.12" . . $14.00

Pyrex diagonals, ⅛ wave accuracy.

Ellipse 1.25" x 1.77" . . $ 5.00
Ellipse 1.5" x 2.12" . . $ 8.00

Aluminum coating $1.00 extra.

Send for our complete list of supplies, quartz mirrors, blanks, oculars, coatings, and accessories.

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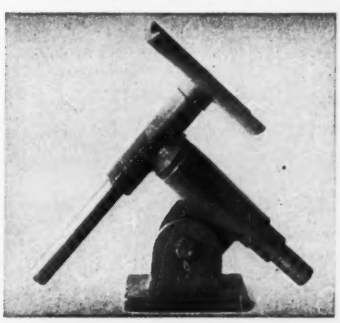
PYREX MIRROR MAKING KITS

Consist of PYREX mirror blank with either plate glass or additional Pyrex for tool. **Six** selected abrasives, pitch, rouge, and cerium oxide.

Diameter	Plate-Glass Tool	Pyrex Tool
6"	$ 8.75	$ 9.75
8"	$11.75	$16.50
10"	$20.00	$29.00
12½"	$36.75	$51.00

Postage Paid to 1st and 2nd postal zones from N. Y. Add 5% 3rd and 4th zones, 10% 5th and 6th zones. Add 15% 7th and 8th zones.



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Heavy cast-iron construction. Adjustable for latitude. Weighs over 30 pounds. 1½" solid steel polar axis. 1¼" solid steel declination axis. Cast-iron saddle, as shown. Shipped only via express collect. **$46.00**

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Brand new! Not surplus or junk. High-powered with ultra-fine resolution. Wide field with full achromatic color correction. Bright image always, even in poor light. Compact, light weight, weather-proof, sturdy. Ideal for spotting, shooting, sighting; for general field use, indoors and outdoors. Crystal-clear observation at all times. Imported. No trial or exchange.

16 x 50 (2") objective. Field, 210 feet at 1,000 yards $18.00

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(Include postage for 2 lbs., either size.)

Case (optional), either size, extra $2.00

TELESCOPE PLANS

Make a good telescope for little money. Complete detailed plans and specifications to make four wonderful Newtonian telescopes first described by Mr. J. V. Lawrence in the June, 1953, issue of *Sky and Telescope*. Complete prints, diagrams, work sheets, bill of materials, photographs of finished parts are included. Every needed help to make each size of telescope you may choose — 3", 4", 5", or 6" — is in this one booklet. Also includes price list of optical necessities.

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FINE TELESCOPE EYEPIECE

Made by Bausch & Lomb

Product of this famous optical house. Well corrected—⅔" e. f. l. (15x). Outside diameter 1¼". Eye lens ¼" diameter; field lens ⅜" diameter. A finely corrected Huygens with high eye relief. Priced very low. Limited stock.

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DESK MAGNIFIER

Handy necessity for home and office. Beautiful pitch polished, pure clear optical crown glass lens mounted in satin-black anodized aluminum ring mount with fluted plastic handle. 3½-power lens, 1⅝" diameter. From choice Govt. surplus. Complete with zippered simulated leatherette case. Worth many times our low, low price!

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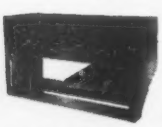
PRISMS — GIANT SIZE



Brilliant crystal white optical crown glass. Dozens of wonderful things to do and make: sunlight rainbows, periscopes, secret pictures with cameras, see around corners, see upside down, etc. 6½" x 2", 45-90°. Aluminized back. Mounted. U. S. surplus cost $22.00. Mrs. H. R., New York, writes, "I have ordered four of these and they are beautiful when taken out of the case." Limited offer.

ONLY $2.50 plus postage on 2 lbs.

Include postage please. No open accounts or C.O.D.'s. Complete catalog — $1.00.

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Telescopes — Microscopes

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In Business Over Quarter Century

Fig. 7. The assembled Springfield head, as seen from the north side.

prism housing. The eyepiece fits in a short tube just above the prism.

To the right of the prism-eyepiece assembly is the locking clutch for vernier adjustment in right ascension; in actual use this clutch is securely tightened with a wrench to insure positive locking. For a tube length of 10 feet and a mounting and tube weight of 350 pounds, the polar axle bolt must be set rather tightly to eliminate wobble of the telescope on the polar bearing; this gives a smooth but very snug motion and the vernier adjustment in right ascension is too tight to do the turning by hand. Therefore, after the clutch is locked with the large hex-headed screw, adjustments are made by placing a ratchet-type socket wrench over the bolt head at the upper right of the locking screw.

Extending around the edge of the plate holding the vernier drive is the right-ascension slip-ring setting circle, with the pointer for this circle located in this picture at the left of the worm that drives in right ascension. The worm gear beneath the circle has 576 teeth. The worm itself is fastened to the lower, fixed casting, and it is driven with a reduction

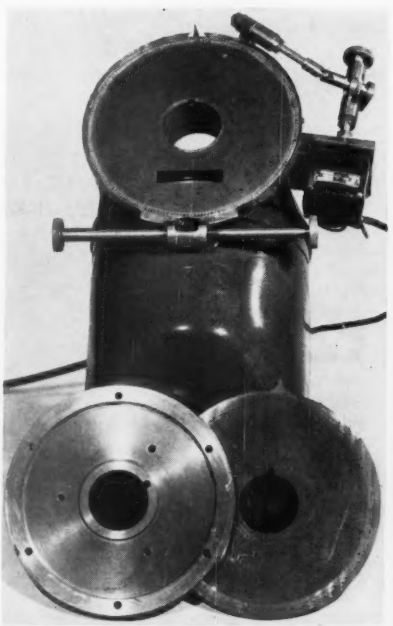

Fig. 8. The south side of the mounting, showing the declination disks.

gear train from a motor inside the base casting to be described later. To the right of the worm gear and extending away from the mounting (toward the reader) is a shaft with a knob. This knob is merely an indicator, while the motor is running, that the worm is driving, because it rotates faster than the worm, and hence the knob's motion is visible. The box to the right of this control is a limit switch which shuts off the motor drive before the tube can strike the pier when it passes through the meridian. (Then, as with a German equatorial, the tube must be swung to the other side of the pier.)

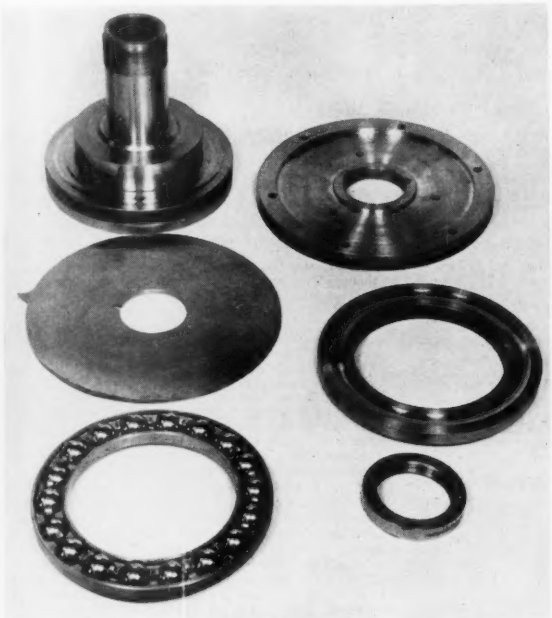

Fig. 9. The declination parts, before assembly, including the locking ring (lower right). These separate parts are also shown assembled in Fig. 10 below, where the divisions on the edge of the declination circle may be seen.

There are four pairs of holes around the base plate, three of which are visible in Fig. 7. Each elongated hole permits turning the mounting on the pier for azimuth adjustment, while the other hole is used in east-west leveling and adjusting the mounting for latitude by changing the elevation. Not shown in this photograph is a later modification, a pair of opposing bolt mechanisms, one on the north and the other on the south side of the mounting base, to provide delicate rotation in azimuth and positive locking on the north celestial pole, a necessity if stellar photography with long exposures is attempted.

In Fig. 8, the declination assembly has been dismantled. At the lower left is the combination worm-wheel and circle containing six rim holes used to attach the saddle; these take socket-head cap screws. To the right is a stainless-steel disk with a spur at the top to engage the fine control in declination, operated by means of the horizontal rod with knurled knobs. The same plate of stainless steel also furnishes the main bearing surface in declination, rotating on the 8-inch circle of small free-rolling ball bearings in the groove around the edge of the face plate of the upper casting, giving a smooth action.

Notice that the hole through the center of the angle casting, the setting circle, and the spur plate are all keyed or slotted to allow assembly of the declination-axle tube with the angle casting without removing the key on the declination-axle tube. The declination drive is clearly seen in the upper right of Fig. 8; it is engaged by loosening the bracket of the worm mounting, pressing into mesh by hand, and then retightening the bracket. The universal joint permits proper fitting of the worm to the worm gear, while the motor and its controls are out of the way.

All parts of the declination assembly are seen in Fig. 9, and they are loosely assembled in Fig. 10. The 7½-inch thrust bearing replaces a former 3½-inch bearing as there was a possibility of flexure in the mounting at this point. After the parts are put together the threaded end of the shaft is inserted into the opening

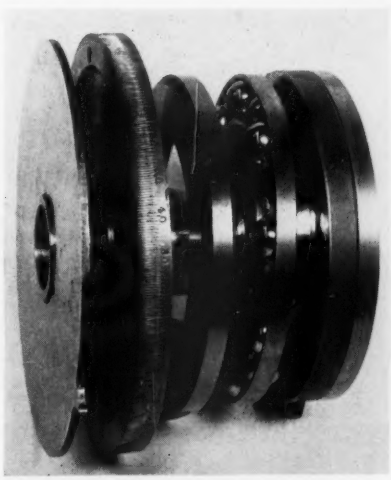

Fig. 10. The declination assembly.

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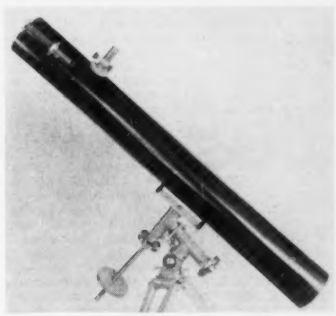

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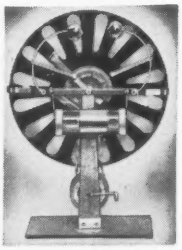

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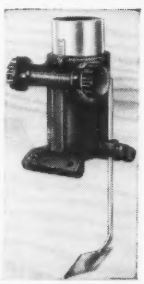

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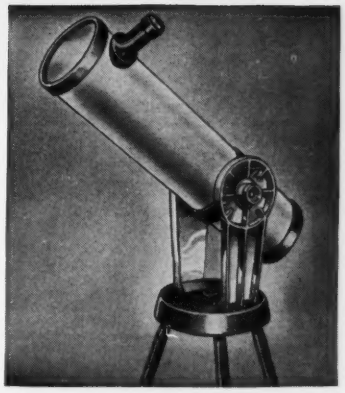

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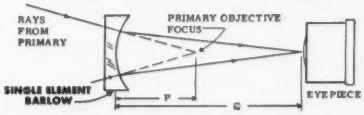

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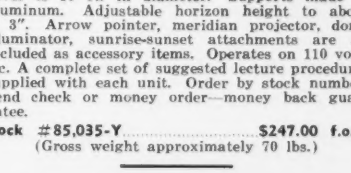

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Fig. 11. The north side of the mounting, with the stud that holds the angle casting in place seen at top center. This stud must be very securely tightened. The parts in the foreground are described in the text.

(Fig. 8), care being taken that the keyed parts are in alignment. The locking ring, in the lower right of Fig. 9, is screwed up tight from the eyepiece side. This ring has an unusual locking arrangement; instead of a set screw in the outside edge, nearly half of its periphery is slotted and an Allen screw is threaded into one half of the face (right in Fig. 9). Tightening this screw forces the split apart, binding the ring against the threaded declination shaft so it cannot work loose. The two holes in the ring face are for tightening the ring with the kind of wrench used on the back of a waterproof watch.

Part of the original declination assembly is included in Fig. 11, but our chief interest here is in the disassembled control for right ascension motion, which consists of all parts shown (except the eyepiece and prism assembly in the lower left, the declination tube at the left, and the declination locking ring at the right). It is well for the reader now to refer to Figs. 12 and 13, where these parts are shown in detail, including the manner in which the clutch lock control rides in a slot on the right-ascension worm gear. Looking at the lower edge of the upper casting (Fig. 11) where the clutch lock is attached, this same channel can just be discerned through the slot in the casting.

The partly threaded long bolt with a hexagonal head, at the lower right of Fig. 11, is hollow, and the thin metal

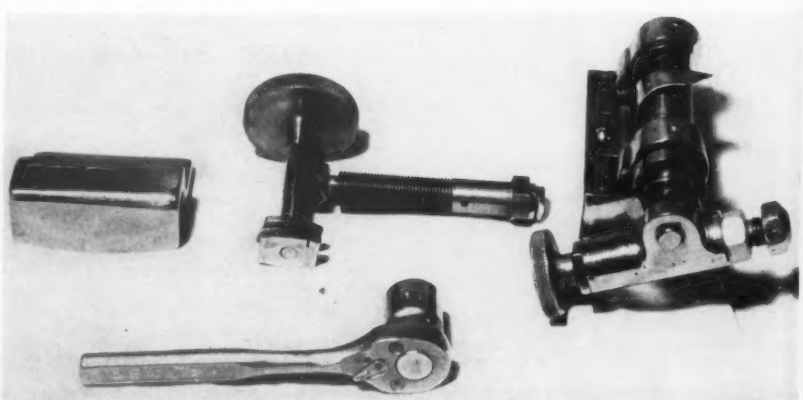


Fig. 12. The clutch mechanism in the center fits into the housing at the left; serrations on the foot grip the clutch plate to prevent slippage. The adjusting wrench is at the bottom, and the drive-connecting assembly at the right.

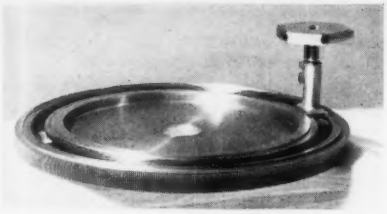


Fig. 13. The clutch locking assembly rides in the groove of the disk that engages the worm gear.

piece lying at right angles to it is inserted its full length. Two nuts hold this piece at one end, while the other end is flat and fits into the slot on the side of the clutch lock, as seen in the center of Fig. 12. The flattened section has a central hole, through which it is fastened with a machine screw to hold the parts together. It is important that the hex-headed bolt rotate freely around the shaft inside it.

In the original plans by Russell W. Porter (*Amateur Telescope Making—Book Two*, page 367), the end of this inner shaft was threaded instead of pivoted, resulting in the clutch lock jamming tight during its operation. Dr. Custer's movable joint is an important change in the design of this control.

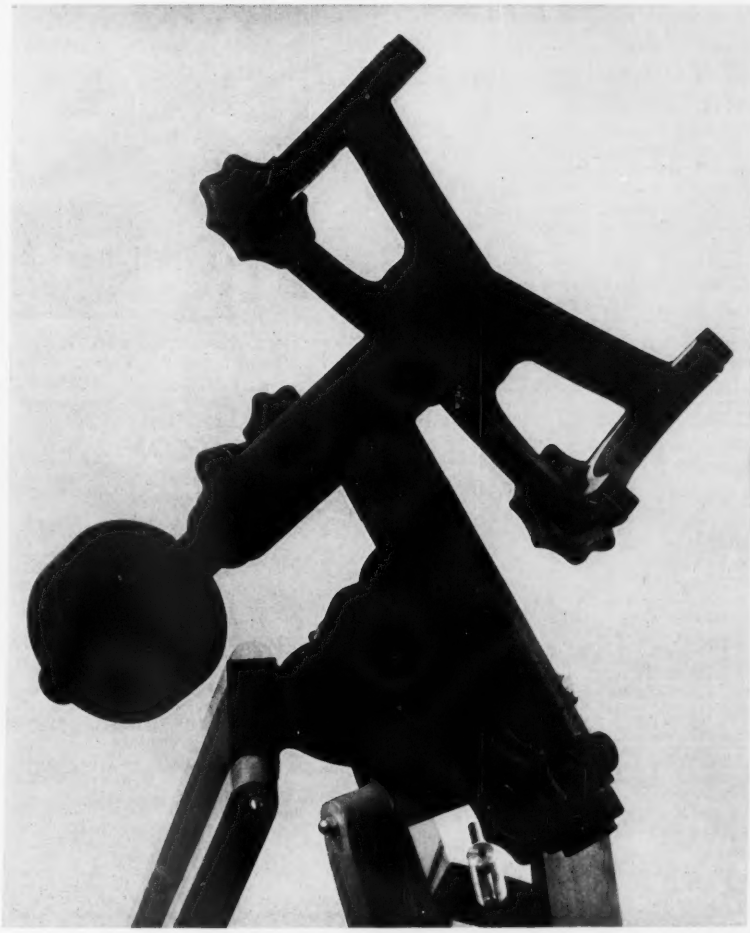
To assemble the unit, the case (left in Fig. 12) is first bolted to the machined surface of the angle casting (Fig. 11, center), then the driving nut and shaft with the inserted pin in place are threaded into the hole located in the right end of the case and the flat section is fitted into the slot. The locking head is then fastened to the clutch through the slotted hole in the top of the case. Then the flattened section of the driving nut and shaft is fastened into the slot of the clutch lock with the machine screw. When the unit is loose, the telescope is free to move in right ascension while the clutch slips around in the channel in the worm gear. But if the clutch is tightened with the large hex nut by means of a box-end wrench, this slippage can no longer occur, and the small hex-headed bolt must be turned with the ratchet wrench (Fig. 12) to make fine adjustments in right ascension.

The detached support for the driving worm is lying against the bottom of the base in Fig. 11, and attached to it, on the right side, is the connection for the reduction gear from the motor. When put into place, the shaft extending toward the mounting is inserted in the hole in the base casting just to the left of the limit-switch box. This leads into the hollow interior of the base casting to the driving motor and differential slow-motion control. This worm unit is seen from another angle at the right in Fig. 12.

Next month we shall discuss more details of the right-ascension assembly and describe the motor drive.

(To be continued)

Here's an Equatorial Mounting Adjustable to Any Latitude



The major parts are aluminum castings, made of virgin alloy #356, T6 heat-treated. The shafts are solid steel, precision ground to 1½ inches in diameter. The lock collars and bolts are also of steel. The polar and declination axis housings are 2½ inches in diameter and 9 inches long, with 4 inches of bearing on each axis. Cast base is 6 inches in diameter. Can be used on a pier or a sturdy tripod.

It is completely machined and is finished in black crackled instrument baked enamel. The mounting weighs approximately 33 pounds and the counterweight 13 pounds. It will rigidly support a 6- or 8-inch mirror of any focal length and a 10-inch mirror of short focal length. Saddles are available for 7-, 8-, 9½-, and 10-inch diameter tubes.

The mounting, complete as pictured less tripod, is priced at **$66.50** f.o.b.; packing charges are $7.00 extra, and it can only be shipped via railway express or truck freight. Immediate delivery.

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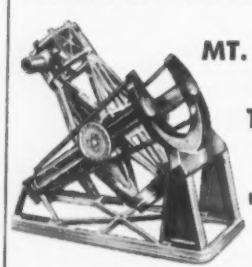

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MAKSUTOV CLUB NOTES

Since the notice on page 533 of the October issue, I have developed a mailing list of over 100 names of persons interested in building a Maksutov type of telescope. The correspondence is heavy, and all interested persons are asked to enclose self-addressed stamped envelopes with their letters of inquiry. The deadline for new "members" has been set for December 15th, at which time I shall ask for estimates of the cost of the glass blanks on the basis of the inquiries in hand.

There are no dues in this club, but as its purpose is to get a reduction in the cost of Maksutov corrector blanks, it is hoped that all members who can do so will place orders. When final specifications have been established and the supplier of the glass selected, you will be notified. Orders should be sent to me, together with check or money order for the full amount payable to the glass supplier. The blanks will be sent directly to the purchasers, who should notify me of their receipt.

The size that appears to be most in demand is a 10-inch clear aperture corrector with a 12½-inch mirror. But members are asked to send in their suggestions concerning design, working of the glass, and general construction of Maksutov telescopes, as the literature on the subject is meager.

ALAN M. MACKINTOSH
97 McLoughlin St.
Glen Cove, N. Y.

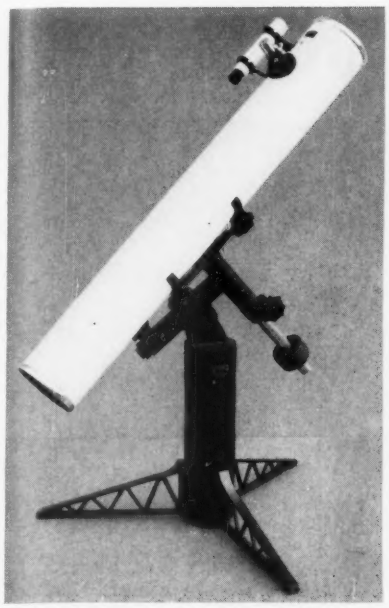
TEMPLATES FOR MIRROR MAKERS

Although many amateurs are satisfied if their finished mirrors come within several inches of the focal length originally aimed at, greater accuracy is often desired. Compound telescopes must be built to close tolerances, while mirror-making classes run more smoothly if all the instruments under construction have the same focal length within an inch. The beginner can easily control mirror radius by using a template having the radius of curvature desired for the mirror. However, templates of about 100 inches are not easy to construct accurately, particularly if shop facilities are limited.

Good plastic templates are commercially available at moderate cost. These are the "railroad curves" used by draftsmen. Each contains both concave and convex curves of equal radius. The railroad curves obtainable from distributors of the Keuffel and Esser Co., for example, come in the following radii: 1½" to 12", in steps of ½"; 12" to 40", in steps of 2"; 40" to 100", in steps of 5"; 100" to 120", in steps of 10"; while curves of 200" to 1,000" in radius are available on order.

These are of good size, the curve of 100" radius measuring about 18" long by almost 2" wide. Individual railroad curves in standard sizes cost about $3 each, those made to order about $7.

ASTROLA Reflecting Telescopes



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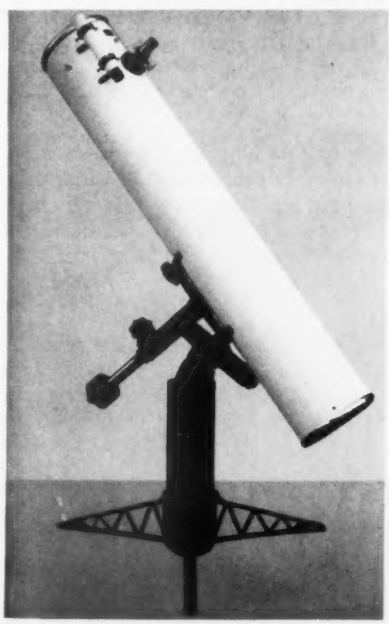

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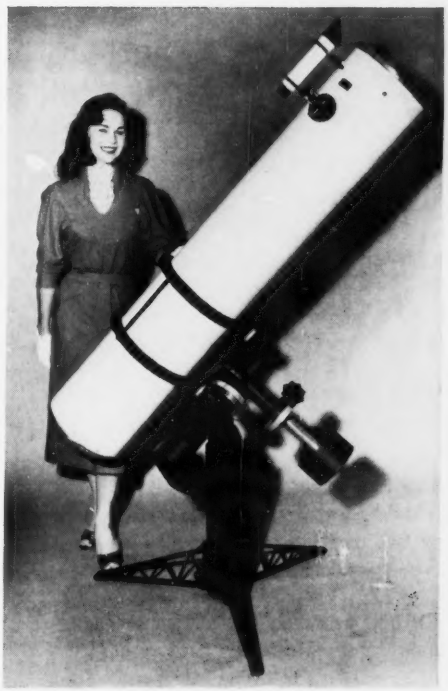

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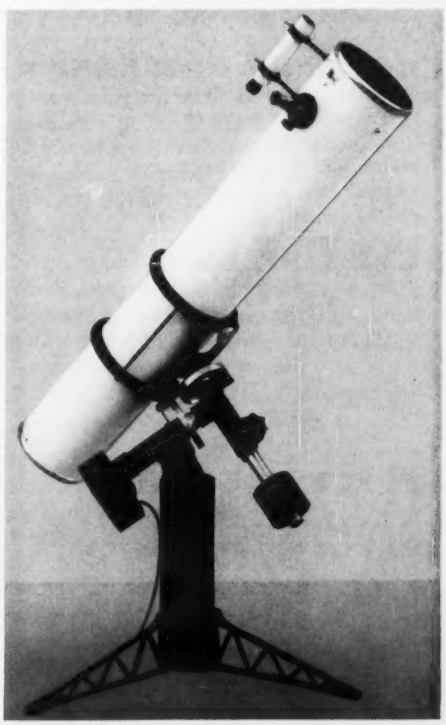

Model "B" De Luxe 8-inch ASTROLA, f/7, complete with setting circles, clock drive, rotating tube, 3 oculars (84x, 210x, 360x) **$575.00**

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

DEEP-SKY WONDERS

SOMETIMES pursuit of the elusive and difficult celestial objects causes us to forget the easier glories. When you tire from straining to detect a 13th-magnitude planetary, try relaxing for a time by turning to some of the better-known Messier objects.

Two of these have our attention this month, with the aid of some recent photographs by Strathmore R. B. Cooke, using the f/3.2 Schmidt camera described in our October issue, beginning on page 560. With a 10-inch primary mirror and a 6-inch correcting plate, this instrument is ideally suited for cluster photography. The clusters shown here are both located in Perseus, well situated for observation in December.

M34 (NGC 1039) is at right ascension $2^h\ 38^m.8$ and declination $+42°\ 34'$ (1950), between Algol and Gamma Andromedae. It is a fine loose cluster just visible to the naked eye. A low power is required to include its almost full-moon diameter in the field of an ordinary telescope. Though full of twinkling points, it is overshadowed by the Double Cluster and is seldom observed by amateurs.

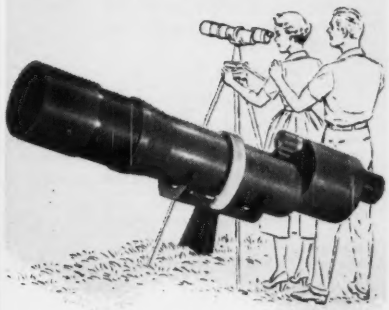
The great Double Cluster, h and Chi Persei, is one of the show objects of northern skies, delighting the novice and intriguing the experienced observer. Lying near the galactic equator, it stands out distinctly to the naked eye, on the prolongation of a line drawn from Gamma through Delta Cassiopeiae. It is located at $2^h\ 17^m$, $+56°\ 54'$. When you have visitors at your telescope, remember that this is one of the very few clusters that can be well seen in partial moonlight.

WALTER SCOTT HOUSTON
Rt. 3, Manhattan, Kans.

Prof. S. R. B. Cooke obtained this photograph of the open cluster Messier 34 with his home-built 6-inch Schmidt camera. With a diameter of about 18 minutes of arc, this group is more than 2,000 light-years distant.

Another of Dr. Cooke's photographs shows the famous Double Cluster in Perseus, enlarged from a 15-minute exposure with the 6-inch Schmidt, which is mounted on a 12½-inch reflector serving as a guide telescope.

THE SKY IS YOURS



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AN OCCULTATION BY MARS

On Tuesday night, December 11-12, observers in the southern United States, as well as in Central and South America, may observe the occultation of a 9th-magnitude star by Mars. The circumstances are predicted in the 1956 *Handbook* of the British Astronomical Association.

Conjunction of Mars and the star (BD +0°16) will occur at 4:44 Universal time on December 12th, corresponding to 11:44 p.m. on the 11th, Eastern standard time. For Washington, D. C., the occultation is listed as grazing, with the star skirting the northern edge of Mars.

At Tacubaya Observatory in Mexico the occultation will begin at 4:48 and last for seven minutes; it will be a minute longer at Quito, Ecuador. For these stations, the star will disappear behind the dark edge of Mars, reappearing at the planet's bright limb.

Observers outside the occultation zone will find the minute-by-minute motion of Mars past the star an interesting sight.

On December 12th at 22:21 Universal time, Mars will be only about 28 seconds of arc from the 7.4-magnitude star BD +0°22.

AURORAE IN COLORADO

Late on the evening of October 1st, at Greeley, Colorado, Dr. J. R. Otoupalik observed a faint auroral glow 10° above the northern horizon, extending from east to west. On the 11th, for 1½ hours beginning at 9:30 p.m. MST, a very noticeable curtain glow was observed beneath Polaris, covering an area about 10° square. Stars seen through this curtain were not dimmed.

TRANSIT OF EUROPA ACROSS GANYMEDE

James McCracken, of Richmond, California, also observed the passage of Jupiter's satellite II in front of III on May 3, 1956, which was reported by M. Francis on page 424 of the July issue. With a 6-inch reflector at 120x, Mr. McCracken recorded the combined image as round. Stephen W. Bieda, Jr., San Jose, California, notes that this transit was predicted in the *Strolling Astronomer,* September-October, 1955. The average of Mr. Francis' beginning and ending times is 10 minutes earlier than the mean of the predicted times.

MOON PHASES AND DISTANCE

New moon	December 2,	8:12
First quarter	December 10,	11:51
Full moon	December 17,	19:06
Last quarter	December 24,	10:10
New moon	January 1,	2:13

	December	Distance	Diameter
Apogee	7, 16h	251,800 mi.	29′ 29″
Perigee	19, 13h	224,500 mi.	33′ 05″
	January		
Apogee	4, 8h	252,400 mi.	29′ 25″

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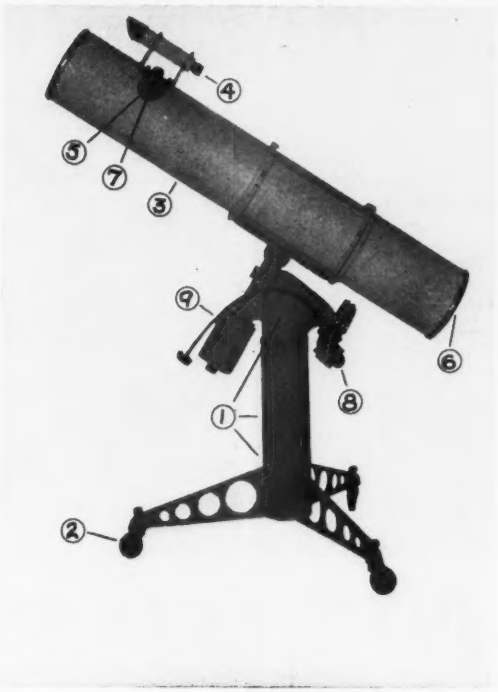

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No precision processing or factory-fresh film was used. We bought our films at a small-town drugstore in Colorado, and after taking pictures left them in our car for a month, where they got mighty warm in the August sun. We didn't take any special care in processing the films on our return but gave them to the photo finisher in our town, who develops and prints everybody's snapshots.

This trip to Colorado was to give our new Linhof De Luxe Tripod and two camera accessory groups a field test in rugged country. Well, they got a real workout, and so did a De Luxe Questar taken from stock. We got caught in showers, were dew-drenched at night, were very hot and very chilly, and more than once the whole outfit was enveloped by a gusty wind blowing dust and gravel. Everything worked perfectly, however, and that tripod is a joy to use. Carries well in a car, too. Did we ever tell you that these beautiful Questars are tough little animals? After the 5,400-mile trip and dousing in dust, our Production Manager inspected the instrument carefully and found it in perfect condition, inside and out, with no evidence of use at all.

Finally, to get to the pictures, the bus was nearly half-a-mile distant; the cabin on the mountaintop, at least a mile away. The two long shots happened to be taken with our $134.50 Hexacon Camera outfit, the covering shots with the Praktica (Rival) Camera of our $99.50 group. Both cameras are sold with all the necessary couplings. We used Eastman Panatomic-X film, which is available everywhere and is noted for its fine grain, permitting great enlargements with little loss of sharpness. Exposure time was 1/50 second at f/12.1, Questar's normal aperture.

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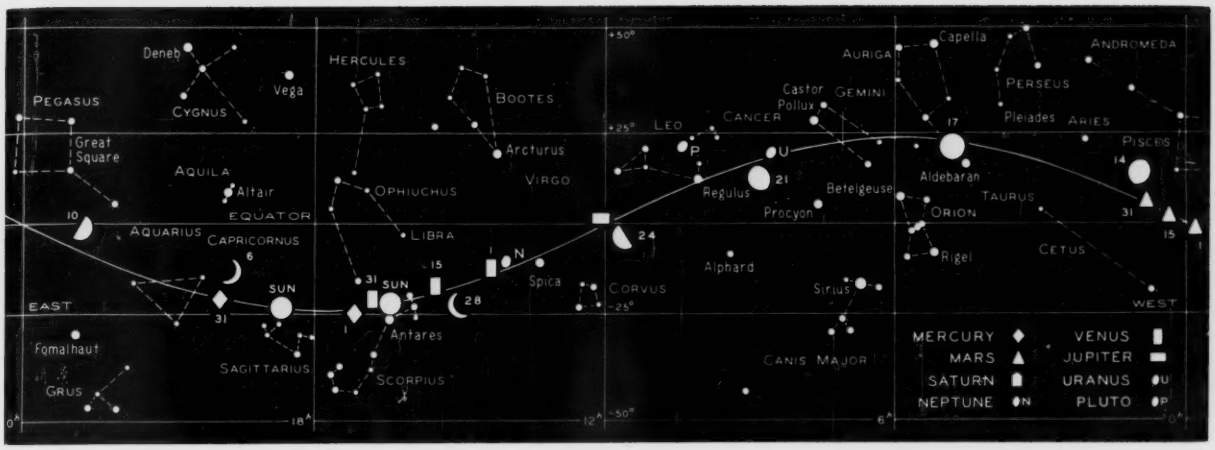

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown.

The sun will be partially eclipsed on December 2nd for observers in most of Europe and Asia. In southeastern England, the sun will rise with the moon covering six per cent of its diameter, but the eclipse will end a few minutes later. The maximum obscuration of the sun's disk will be about 80 per cent, near the Arctic Circle in the U. S. S. R.

Mercury will be favorably placed for observing this month, reaching its greatest eastern elongation of 19° 53′ on December 25th, at magnitude −0.3. However, the planet may be observed as early as the 8th, when it sets about an hour after the sun. On Christmas day, Mercury will set 1½ hours after sunset, thus providing an excellent object for viewing by recipients of new telescopes.

Venus rises 2½ hours before the sun at midmonth, appearing at magnitude −3.4. The disk of the planet is slowly decreasing as its phase approaches full; on the 15th the disk is 12″.0 in diameter and 87 per cent illuminated.

Venus and Saturn will be close together on the mornings of December 26th and 27th, for they are in conjunction on the 26th at 21^h, with Venus passing 30′ south of Saturn. And on the morning of the 29th, these planets and the moon will be near each other in the eastern sky.

Earth arrives at heliocentric longitude 90° on December 21st at 21:00 UT. Winter commences in the Northern Hemisphere and summer in the Southern.

Mars appears as a bright reddish object moving eastward in Pisces. The planet fades to magnitude 0 by December 15th, with a corresponding decrease, to 10″.3, in the size of its disk. This is the last opportunity of the present apparition to observe Mars effectively with amateur instruments.

Jupiter reaches western quadrature with the sun on December 22nd, when the planet rises about midnight, very close to the east point of the horizon. At magnitude −1.6, the giant planet will then be 36″.9 in equatorial diameter.

Saturn becomes visible in the morning sky about the 15th of the month, when it will rise about one hour before the sun. Two interesting configurations involving Saturn are described under Venus.

Uranus can be observed with slight optical aid, as a 6th-magnitude object moving slowly westward about 1° southwest of the Beehive cluster (M44) in Cancer.

Neptune cannot be observed until just before dawn in the morning sky. This distant planet is moving slowly eastward, about 10° east of Spica in Virgo.

E. O.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

MINIMA OF ALGOL

December 1, 22:40; 4, 19:29; 7, 16:18; 10, 13:07; 13, 9:57; 16, 6:46; 19, 3:35; 22, 0:24; 24, 21:13; 27, 18:02; 30, 14:52. January 2, 11:41; 5, 8:30; 8, 5:19; 11, 2:08.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

OCCULTATION PREDICTIONS

Data for the occultation of Omega Tauri on December 15-16, for stations **F** and **H**, appeared on page 47 last month.

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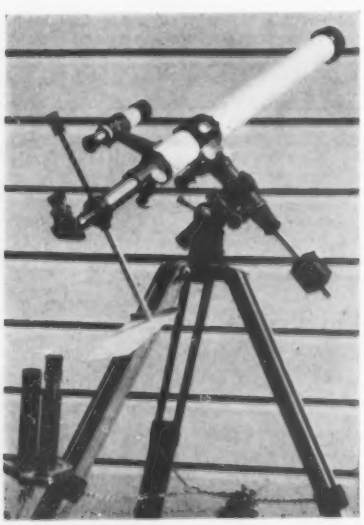

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DECEMBER METEORS

Moonlight will interfere somewhat with observations of the Geminid meteor shower, whose maximum occurs on December 12-13. That night the moon will be in Pisces, 2½ days past first quarter, setting in the early morning. Under favorable conditions, the predicted rate is 40 meteors per hour. The shower will last several days; its radiant is at right ascension $7^h\ 32^m$, declination +32°, not far from Castor.

The December Ursids will appear only on the night of the 21-22, with a predicted rate of 15 meteors per hour. The radiant is at $13^h\ 48^m$, +80°. At that time the moon will be in Leo, two days before last quarter. E. O.

SUNSPOT NUMBERS

September 1, 147, 168; **2,** 157, 158; **3,** 133, 136; **4,** 121, 138; **5,** 116, 146; **6,** 137, 168; **7,** 141, 176; **8,** 128, 174; **9,** 113, 161; **10,** 123, 136; **11,** 160, 175; **12,** 205, 208; **13,** 222, 244; **14,** 249, 280; **15,** 245, 276; **16,** 230, 253; **17,** 222, 250; **18,** 210, 219; **19,** 209, 228; **20,** 215, 240; **21,** 175, 216; **22,** 129, 153; **23,** 128, 139; **24,** 132, 125; **25,** 130, 132; **26,** 150, 136; **27,** 110, 131; **28,** 110, 127; **29,** 117, 172; **30,** 121, 201. Means for September: 159.5 American, 182.2 Zurich.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by Dr. Sarah J. Hill from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

Zurich provisional sunspot numbers are transmitted by the Swiss Broadcasting Corporation by short wave on the 4th and 5th of the following month. Listeners in North America can hear these reports on the 5th of each month at 01:35 UT on wave lengths of 48.66, 31.46, and 25.28 meters, and at 04:20 UT on wave lengths of 31.46 and 25.28 meters. Reports beamed to South America at 23:30 UT on the 4th and at 03:45 UT on the 5th are on 31.46 and 25.28 meters. This revised schedule will be used until and including April, 1957.

VARIABLE STAR MAXIMA

December 1, T Centauri, 133**633,** 6.1; 2, R Ophiuchi, 170**215,** 7.6; 4, R Normae, 152**849,** 7.2; 7, R Bootis, 143227, 7.3; 10, S Hydrae, 084**803,** 7.9; 14, RU Cygni, 213**753,** 8.0; 17, V Cassiopeiae, 230**759,** 7.9; 25, S Carinae, 100**661,** 5.7; 29, S Sculptoris, 001**032,** 6.8; 31, T Columbae, 051**533,** 7.6; 31, S Pavonis, 194**659,** 7.3.

January 1, S Ursae Majoris, 123961, 7.9; 4, R Reticuli, 043**263,** 7.7; 4, RT Cygni, 194048, 7.4; 6, S Canis Minoris, 072708, 7.5.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

STARS FOR DECEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of December, respectively; also, at 7 p.m. and 6 p.m. on January 7th and 23rd. For other dates, add or subtract ½ hour per week.

December marks the height of the season for naked-eye observation of star clusters. Striking examples are the Double Cluster in Perseus, high in the northern sky; the Hyades; and the Pleiades—perhaps the best-known cluster to amateur skygazers.

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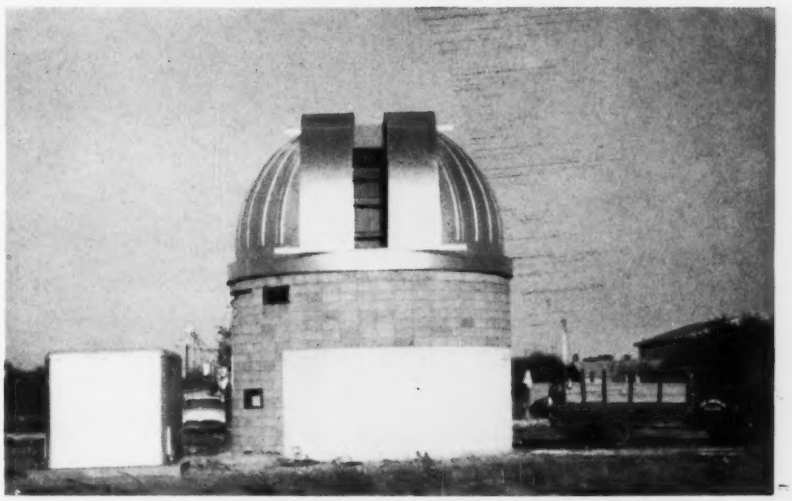

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